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AUTHOR Hale, Gordan A.; Piper, Richard A.
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ABSTRACT

Incidental learning in 8- and 12-year-old children was assessed with a variety of stimulus materials. Experiment 1 compared two types of material; (a) geometric figures, whose central and incidental components were shape and color, respectively and (b) stimuli whose components were separate pictures, as in the typical developmental study of this topic. Incidental learning was found to increase significantly across ages when measures with the colored shapes but not with the pictorial materials. To identify the factors responsible for this difference, Experiment 2 employed these same two types of stimulus along with three others, including shape outlines on colored backgrounds. Again, the task with colored shapes proved to be unique, in that the incidental learning scores for this measure tended to increase across ages and were significantly higher overall than those for the other tasks. Also, correlational analyses based on data from both experiments indicated a positive relation between central and incidental learning with the colored shapes but not with the pictorial materials. These results were interpreted to suggest that stimulus materials whose components are integrated into a single unit, such as color and shape, are functionally different from stimuli with spatially or conceptually independent components. (Author)

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SOME CRITICAL STIMULUS DIFFERENCES

Gordon A. Hale and Richard A. Piper

Educational Testing Service
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Abstract

Incidental learning in 8- and 12-year-old children was assessed with a variety of stimulus materials. Experiment 1 compared two types of material--(a) geometric figures, whose central and incidental components were shape and color, respectively and (b) stimuli whose components were separate pictures, as in the typical developmental study of this topic. Incidental learning was found to increase significantly across ages when measured with the colored shapes but not with the pictorial materials. To identify the factors responsible for this difference, Experiment 2 employed these same two types of stimulus along with three others, including shape outlines on colored backgrounds. Again, the task with colored shapes proved to be unique, in that the incidental learning scores for this measure tended to increase across ages and were significantly higher overall than those for the other tasks. Also, correlational analyses based on data from both experiments indicated a positive relation between central and incidental learning with the colored shapes but not with the pictorial materials. These results were interpreted to suggest that stimulus materials whose components are integrated into a single unit, such as color and shape, are functionally different from stimuli with spatially or conceptually independent components.

DEVELOPMENTAL TRENDS IN CHILDREN'S INCIDENTAL LEARNING:

SOME CRITICAL STIMULUS DIFFERENCES[1]

Gordon A. Hale and Richard A. Piper

Educational Testing Service

With the recent formulation of theories concerning selective attention (e.g., Broadbent, 1958; Neisser, 1967), there has been an increased interest in the related topic of incidental learning. Studies of this topic with children have typically involved stimuli with certain features defined as "central" for learning and others defined as "incidental," and the degree to which subjects acquire incidental stimulus information is frequently assumed to reflect the relative amount of attention devoted to this information. The most comprehensive developmental research on this topic has been conducted by Hagen and his associates, who have observed that children show little or no increase in incidental learning between middle childhood and adolescence, while exhibiting marked improvement in ability to perform a central learning task (e.g., Druker & Hagen, 1969; Hagen, 1967; Hagen & Sabo, 1967; Maccoby & Hagen, 1965). Described more concisely as an increase with age in the <u>ratio</u> of central to incidental learning, this result has been interpreted to suggest a developmental change toward greater attention to stimulus features critical for learning, at the expense of attention to extraneous or incidental information. Other investigators have also obtained results essentially consistent with this interpretation (e.g., Siegel, 1968; Siegel & Stevenson, 1966).

While the generality of these results has been established across procedural variation of several types, the central and incidental stimulus components in most of the studies cited have been discrete, independent pictures, and this could be viewed as a critical limitation with respect to theory. Selective attention has generally been defined as a central process, involving the selection of information for concentration of thought, rather than the more peripheral process of orienting one's gaze in a particular direction. Yet it could be argued that the spatially distinct pictures typically used to study children's incidental learning may actually be tapping the latter process to a relatively great extent. That is, beyond a subject's initial decision to focus on a particular picture in a stimulus complex, his ability to maintain a visual orientation to that picture may play a large role in determining how much he learns about other, "incidental" pictures. Thus, the evidence discussed above may actually reflect a developmentally increasing ability to avoid directing one's gaze toward incidental stimulus information, rather than an ability to resist concentrating one's thought on such information. A purer test of the latter process, it is argued, requires the use of stimuli whose central and incidental components are contained within the same visual area, to ensure continual exposure to both features. This would be true, for example, of stimuli whose components are "dimensions" such as shape, color, and so forth, which are frequently used in other attention-related research (e.g., Suchman & Trabasso, 1966; Zeaman & House, 1963).

The distinction between multidimensional materials and stimuli with spatially independent elements has also been drawn by other investigators (Postman, 1964; Garner, 1970), with evidence suggesting that, for adults at least, these two types of stimulus may be quite different in function. To determine the developmental relevance of this distinction, the present study assessed age differences in children's incidental learning with examples of each of these two types of stimulus material. Two experiments were conducted, and each experiment focussed on developmental changes between ages 8 and 12, since much of the research discussed above has emphasized the years between middle childhood and early adolescence as an important period in the development of selective attention.

Experiment 1

Incidental learning in 8- and 12-year-old children was examined with two types of stimulus material in this experiment. The materials in one case were pairs of adjacent pictures (line drawings) similar to those used in previous studies (e.g., Hagen, 1967; Hagen & Sabo, 1967), while in the other case the stimuli were geometric figures whose central and incidental components, respectively, were shape and color.[2]

Method

Subjects

A total of 80 children in grades 3 and 7 participated in the experiment (mean ages = 8.7 and 12.7 years, respectively), drawn from an elementary and a junior high school in a middle class area of Bucks County, Pa. Subjects at each age level were randomly assigned to either of the two tasks to be described below to yield 10 boys and 10 girls in each group.

Materials

For the Pictures task, the primary materials used in the central learning phase consisted of six pairs of line drawings, each roughly 6 cm. in height and width (see Figure 1, top row). The "central"

Insert Figure 1 about here

component of each stimulus was a picture of an animal, and the "incidental" component was a picture of a household object. In the Colored Shapes task, the primary stimuli were six geometric figures of different colors on black backgrounds (each about 7.5 cm. in height and width); the central component of each stimulus was its shape and the incidental component was its color. The shapes used in this task can be seen in Figure 1 (second row from top), and the colors were blue, orange, gold, gray, green, and pink. Other stimuli used in the Pictures task, for purposes to be described below, were (a) cards containing pictures of the animals alone and (b) cutouts of the household objects. Other stimuli used in the Colored Shapes task were (a) white shapes on black backgrounds, (b) colored cards, and (c) black cards with a shape cut from the center of each.

Procedure

Central learning phase. The procedure used in both tasks was identical to that described by Hagen (1967). The initial phase contained 12 trials of a short-term-memory measure (adapted from Atkinson, Hansen, & Bernbach, 1964), and on each of these trials the subject was shown the six primary stimuli (picture pairs or colored shapes) in a horizontal array on a 55 cm. x 13 cm. card. After the array had been displayed for five seconds, it was turned face down, and the subject was shown a "cue card" containing only the central component (animal or white shape) from one of the six stimuli. He was asked to point to the position of the array in which he had seen that particular animal or shape. After the subject had made his response, the array was reexposed briefly to provide feedback, followed by presentation of the next trial. The same six primary stimuli were used on all 12 trials, so that a given animal was always paired with the same object (or a given shape with the same color), but the arrangement of stimuli across the array varied from trial to trial. The number of trials on which the subject responded correctly in this phase constituted his central learning score.

A practice trial with a two-stimulus array preceded the central learning phase, and the stimuli of this practice trial were similar in nature to those encountered in the main task--i.e., animal-object pairs or colored shapes--but were different instances of these categories; the practice trial was repeated for any subject who responded incorrectly. In the central learning phase, the particular animal or shape presented as a cue on each trial was randomly determined, with the restrictions that (a) each cue appear twice across the 12 trials and (b) no position be correct less than once nor more than three times. The task was presented by means of six array cards, shown twice to yield 12 total trials, and the placement of the six stimuli on these six cards formed a latin-square; thus, across the 12 trials, each stimulus appeared twice in each position. The trials were presented in immediate succession, except for a delay of approximately 20 seconds between trials six and seven to rearrange the cards.

<u>Incidental learning test</u>. Following the central learning phase, an incidental learning test was administered, in which the six household objects (or six colored cards) were placed on the table and the subject was shown the six animals (six shapes) one by one. As the first animal (shape) was shown, it was explained that the subject had seen that particular animal (shape) during the previous task and that "it had another picture with it" ("it was a particular color"). The subject was asked to point to that picture (color) on the table and was allowed to juxtapose the central and incidental components to facilitate

recognition. For this purpose, cutouts of the household objects were used in the pictorial task, and the figural task used black cards with shapes cut from them, which could be superimposed on the colors to "recreate" the central learning stimuli. The subject was asked to respond similarly as he was shown each of the other animals (shapes), and the number of correct responses on this test comprised the subject's incidental learning score.

Experimental Design

The two major variables of the study were Age (8 and 12 years) and Task (Pictures and Colored Shapes), with 20 subjects in each of the four subgroups defined by these variables. Each group contained an equal representation of (a) the two sexes, (b) two orders in which the array cards of the learning phase were presented, (c) two orders in which the cue cards were presented, and (d) two orders in which the incidental learning stimuli were presented. Factors "b" through "d" were completely counterbalanced with respect to sex, and counterbalanced as nearly as possible with respect to each other.

Results

The central and incidental learning scores for the four subgroups of the experiment are presented in Table 1. It will be observed, first of all, that the central learning scores increased from ages 8 to 12 in both tasks. This is consistent with the results of research cited above, and is to be expected, as it reflects an increase in children's ability to learn critical stimulus information. An analysis of variance of these central learning scores, with Age, Task, and Sex as factors, indicated the main effect of Age to be highly significant ($\underline{F}(1,72) = 30.78$, $\underline{p} < .001$), with no other effect approaching significance ($\underline{F} < 1$ in all cases).

Insert Table 1 about here

Of greater concern for the present analysis are differences in the incidental learning scores. For the Pictures task, the results essentially replicated those obtained in previous studies with a similar measure (e.g., Druker & Hagen, 1969; Hagen, 1967), in indicating little developmental difference in incidental learning. For Colored Shapes, however, a marked increase in incidental learning was observed across age levels, and an analysis of variance of these scores, with Age, Tasks, and Sex as factors, indicated the interaction between Age and Tasks to be significant ($\underline{F}(1,72) = 6.59$, $\underline{p} < .05$). The main effect of Age was also significant ($\underline{F}(1,72) = 7.34$, $\underline{p} < .01$), and the effect of Tasks approached significance ($\underline{F}(1,72) = 3.44$, $\underline{p} < .10$); however, these latter effects can be attributed solely to the developmental difference in scores for the figural task (simple effect: $\underline{F}(1,72) = 13.92$, $\underline{p} < .001$), in contrast with the lack of such a trend for the pictorial materials. These results thus provide an initial basis for concluding that the two types of stimulus material used here are functionally different with respect to assessment of children's incidental learning.

One other analysis pertinent to this conclusion involves correlations between the central and incidental learning scores, computed separately for each task. For the Pictures task, these correlations were .23 for Age 8 and .12 for Age 12, while for Colored Shapes they were .38 and .30, respectively. Averaged across age levels, the correlations were .18 for Pictures and .34 for Colored Shapes, the latter of which was significant at the .05 level. Thus, only for the task involving colored shapes was a significant relation observed between the children's performance on the central learning phase and their recall for incidental stimulus information.

To assess the influence of the stimulus orders listed under "Experimental Design," additional analyses of variance were performed. The effect of each of the three order variables was examined in combination with Age and Tasks, to yield a total of six analyses, three for central and three for incidental learning. Of all effects involving Order in these analyses, only one yielded an F statistic higher than the (uncorrected) critical value, which would be expected by chance. The order of cue cards in learning interacted with Age in the analysis of incidental learning scores ($F(1,72) = 4.83$), such that the age difference in scores, although in the same direction in both cases, was greater for one order than the other.

Experiment 2

Examination of the materials used in Experiment 1 suggests that several factors may have contributed to the observed difference in pattern of incidental learning scores. The two types of material differed, first of all, in the spatial separation of the central and incidental components. That is, the animal and object pictures were separate, distinct elements (although adjacent), while shape and color were contained within a single stimulus unit. To assess the role of this factor a third task, "Shape-Color Separated," was included in Experiment 2 along with the two measures from the first experiment. In this task, each stimulus consisted of a shape adjacent to a colored patch, so that the central and incidental components of the stimuli were shape and color, as in the Colored Shapes problem, but were spatially separated in a manner analogous to the pictorial measure.

The results can also be explained in terms of a second factor, the integration of stimulus features. The colors and shapes were integrated in the sense that they formed a unitary stimulus, and thus both of these components may have elicited attention, not simply because they were contained within the same spatial area, but because they were viewed as integral parts of a whole. To test this possibility, a fourth task, "Colored Background," was also included in Experiment 2. Shape and color were again the central and incidental stimulus components, but in this case color formed the background for a black outline of a geometric figure. Here, color was necessarily contained within the subject's field of vision as he viewed the shapes, but the two components formed a figure-ground relationship and were thus conceptually independent entities.

The effects observed in Experiment 1 could also be attributed simply to the use of pictorial materials versus geometric figures as stimuli, or to the uniqueness of color as an incidental cue. Although the comparisons described above contribute information in this regard, a further test of these alternatives was provided by a task entitled "Animal-Color Separated." With stimuli comprised of animal pictures and adjacent colored patches, the task differed from Shape-Color Separated only in the nature of the central stimulus component, while it differed from Pictures only in the nature of the incidental component. The experiment included children of ages 8 and 12, and developmental trends in incidental and central learning were examined for each of the five tasks described.

Method

Subjects

A total of 158 children at ages 8 and 12 were included (means = 8.7 and 12.7 years), drawn from third- and seventh-grade classes in a middle-class area of northern New Jersey. Children at each age level were randomly assigned to the five tasks, to yield 16 subjects in each group (eight boys and eight girls), except for two subgroups containing 15 subjects as noted below.

Materials and Procedure

The basic format of the measure used in Experiment 1 was employed, with a 12-trial short-term memory task as a central learning phase, followed by a test of incidental learning. Five different tasks were constructed according to this format, differing in the type of stimulus material used in each case, and these tasks are pictured in Figure 1. The stimuli for two of these tasks, Pictures and Colored Shapes, were identical to those of Experiment 1 except that, for the latter measure, the colors brown and yellow were substituted for gray and gold, and the incidental learning test cards were white shapes on a black background (rather than black cards with shapes cut from them). In the Colored Background task each of the primary stimuli consisted of a black outline of a geometric figure on a colored background. The shape component was designated as central, and the cue cards and incidental test cards contained black outlines of shapes, of the size pictured, on white backgrounds. In Shape-Color Separated the central component of each stimulus was a shape outline on a white background and the incidental component was an adjacent colored patch. The cue cards and incidental test cards were outlines of shapes on white backgrounds, comparable in size to those shown in Figure 1. Animal-Color Separated was similar to this last problem except that the central component of each stimulus was an animal rather than a shape, and the cue cards and incidental test cards were animal pictures. In all of the last three measures, colored cards were used to elicit the subject's responses in the incidental learning test, and the colors were the same as those used in the Colored Shapes problem.

All tasks were presented as described in Experiment 1 (including the practice trial) with the following exceptions: (a) the stimulus array was displayed for six rather than five seconds on each trial to ensure that all subjects would have sufficient time to study the array, (b) the subjects were simply asked to point to the object (color) that was correct for each animal or shape in the incidental learning test, as few subjects in Experiment 1 had actually attempted to "recreate" the stimuli, and (c) the instructions were varied slightly across tasks to conform with the materials involved.

Experimental Design

The two major variables of the experiment were Age (8 and 12 years) and Tasks (five levels), and each of the 10 resulting subgroups contained 16 subjects, except for Colored Shapes and Shape-Color Separated which contained 15 subjects at the 8-year age level. The control variables listed in Experiment 1 were also introduced here--two orders each of array cards, cue cards and test cards--along with two different stimulus sets differing in the object (color) paired with each animal (shape). Each subgroup was balanced for sex and these control variables, except for the two groups with 15 subjects, which were balanced on these factors as nearly as possible.

Results

Table 2 presents the central and incidental learning scores for each subgroup of the experiment. An analysis of variance of the central learning scores, with Age, Tasks, and Sex as factors, revealed the effect of Age to be highly significant ($F(1,138) = 41.41$, $p < .001$), while no other effect reached significance. Analysis of the incidental learning scores, again with Age, Tasks, and Sex as factors, indicated the only significant effect to be that of Tasks ($F(4,138) = 3.92$, $p < .01$); this effect was apparently attributable to the high scores for Colored Shapes, which averaged 2.73 across all subjects, relative to the scores for the other four tasks, which averaged between 1.42 and 1.85. According to a Newman-Keuls test, Colored Shapes differed significantly from the other four problems in incidental learning scores ($p < .05$), but the latter did not differ significantly from each other. The Colored Shapes task was unique in another respect as well, as this was the one measure for which a marked increase across age levels was observed in the incidental learning scores. Although the simple effect of Age within Colored Shapes only approached significance in this experiment ($F(1,138) = 3.39$, $p = .07$, two-tailed test), the fact that a similar effect was observed in Experiment 1 is evidence of its consistency.

Insert Table 2 about here

Correlations were computed between the central and incidental learning scores for each Age x Task subgroup, and the data of initial interest involved the Pictures and Colored Shapes tasks, to compare with the results observed in Experiment 1. Again, moderate positive correlations were observed for Colored Shapes (Age 8: .37, Age 12: .31) but not for Pictures (Age 8: .15 and Age 12: -.32), and the average correlation for Colored Shapes, .34, approached significance ($p < .10$). Thus, while not of great magnitude, the positive relation between central and incidental learning for Colored Shapes observed in both experiments of this study appears to be a relatively consistent effect (the combined p level across experiments is .05 x .10, or .005). For the remaining tasks the correlations were based on the sample from the second experiment alone and can thus be interpreted in only a limited way. At the least, however, these correlations are sufficient to indicate that the positive relation observed for Colored Shapes is not characteristic of these other three measures. The correlations, for ages 8 and 12, respectively, were: Colored Background, -.19 and .13; Shape-Color Separated, -.34 and .23; and Animal-Color Separated, -.21 and -.14.

The influence of the various stimulus sets and orders was assessed in a manner similar to that of Experiment 1. Eight separate analyses of variance were conducted, four for central and four for incidental learning, and the factors in each analysis were Age, Tasks, and one of the four control variables. Again, only one effect involving a control variable produced an F exceeding the critical value, as expected by chance; the order of cue cards in learning interacted with Tasks in the analysis of incidental learning scores ($F(1,138) = 3.29$). Thus, although the scores for Colored Shapes were higher than those of the other tasks for both orders, different rank-orders of the latter tasks were observed in these two cases.

General Discussion

Stimuli whose components are contained within a single unit, such as colored shapes, appear to be functionally different from the type of pictorial stimuli that have usually been employed to measure children's incidental learning. As evidence for this conclusion, markedly different developmental trends were observed for these two types of material, with incidental learning increasing across age levels only for the task involving colored shapes. The Age x Task interaction was significant in the first experiment, and results in the same direction in Experiment 2 point to the reliability of this effect. Additional analyses indicated a significant positive correlation between central and incidental learning for the colored shapes but not for the pictorial stimuli, providing an additional basis for regarding these materials as functionally different.

A major factor contributing to this difference, according to Experiment 2, is the degree of integration, rather than the spatial coordination, of central and incidental elements. The results obtained when color and shape formed a single unit were not observed when the colors served as backgrounds for the shapes; the amount of incidental learning in the Colored Background task was relatively low, did not increase with age, and did not correlate significantly with central learning. Given these results it is apparent that the singular results for Colored Shapes cannot stem simply from a spatial coordination of components, since the incidental information was continuously present in the subject's visual field in the Colored Background task as well. Neither does the specific use of shape and color as stimulus elements appear to be the critical factor, given the similarity in results among all four other tasks. Rather, the uniqueness of the task involving colored shapes appears to derive largely from the integration of the stimulus components used; shape and color in this case were both contained within a single stimulus unit, and since these are common features of objects, they were likely perceived by the children as integral parts of a whole.

It is hypothesized that, if a stimulus is readily separable into components, then as children grow older they will increasingly attend only to those stimulus features that are critical for task performance and ignore other aspects. That is, older children realize the advantage of attending exclusively to task-relevant stimulus features, and this developmental difference in strategy will become manifested in performance when the relevant and extraneous stimulus components are easily separable. However, when the components are integrated into a single unit, such as is true of shape and color, children of all developmental levels will attend to both of these components in discriminating among stimuli. In this case, even though older children may be potentially more prone to use a focused attentional strategy, children of all ages will nevertheless attend to extraneous as well as relevant stimulus features, viewing such features as integral parts of a unitary stimulus.

Among the implications of the present results, it is apparent that care must be exercised in comparing evidence from the various paradigms that have been regarded as measures of selective attention. Some of these paradigms have used stimuli whose components are separate entities--for example, independent pictorial elements as in many of the incidental learning studies cited above, or independent verbal elements as in certain measures of component selection (see Richardson, 1971). Other measures however, have employed stimuli whose components are shape, color, size, and other dimensions along which objects typically differ. Included in this category are tests of children's "dimension preferences" (e.g., Brian & Goodenough, 1929; Suchman & Trabasso, 1966), concept identification tasks (e.g., Zeaman & House, 1963), and discrimination shift problems (see Wolff, 1967). Although these various measures have been concerned with different aspects of the attentional process, all employ multicomponent stimuli and have been cited as bearing in some way on the process of selective attention to stimulus components. Yet as the present study has shown, it would be incorrect to treat the various types of stimuli used as functionally similar and to regard the general class of "multicomponent stimuli" as a unitary category. Rather, it is imperative to take into account stimulus factors of the type studied here that may be critical with respect to measurement of children's attention.

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Footnotes

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[2]Color was incidental for all subjects, since children of these ages attend primarily to the shapes of the stimuli used here (Hale & Morgan, 1971); it is felt that measurement of learning that is truly "incidental" requires that the stimulus component defined as incidental be a feature to which subjects would not naturally direct the majority of their attention.

Table 1

Means and Standard Deviations (in Parentheses) of Scores

for Tasks Employed in Experiment 1

($\underline{N}$ = 20 in Each Group)

	Central Learning		Incidental Learning	
Task	Age 8	Age 12	Age 8	Age 12
Pictures	3.70	6.40	1.70	1.75
	(1.30)	(2.37)	(1.08)	(1.62)
Colored Shapes	4.15	6.45	1.45	3.30
	(1.66)	(2.42)	(1.47)	(1.89)

Table 2

Means and Standard Deviations (in Parentheses) of Scores

for Subgroups of Experiment 2

	Central Learning		Incidental Learning	
Task	Age 8	Age 12	Age 8	Age 12
Pictures	3.75	6.63	1.81	1.50
	(1.65)	(1.93)	(1.17)	(1.10)
Colored Shapes	4.27*	6.13	2.27*	3.19
	(2.12)	(2.36)	(1.83)	(2.07)
Colored Background	3.88	5.44	1.94	1.75
	(1.71)	(2.16)	(1.65)	(1.34)
Shape-Color Separated	3.73	4.81	1.27	1.56
	(1.03)	(1.80)	(1.22)	(1.09)
Animal-Color Separated	3.69*	6.19	2.00*	1.13
	(1.92)	(2.48)	(2.00)	(1.02)

* N = 15; all other groups, N = 16

Figure Caption

Fig. 1. Stimuli of the five tasks in the study. From top to bottom rows, the tasks are: Pictures and Colored Shapes (used in Experiments 1 and 2); Colored Background, Shape-Color Separated and Animal-Color Separated (used in Experiment 2).

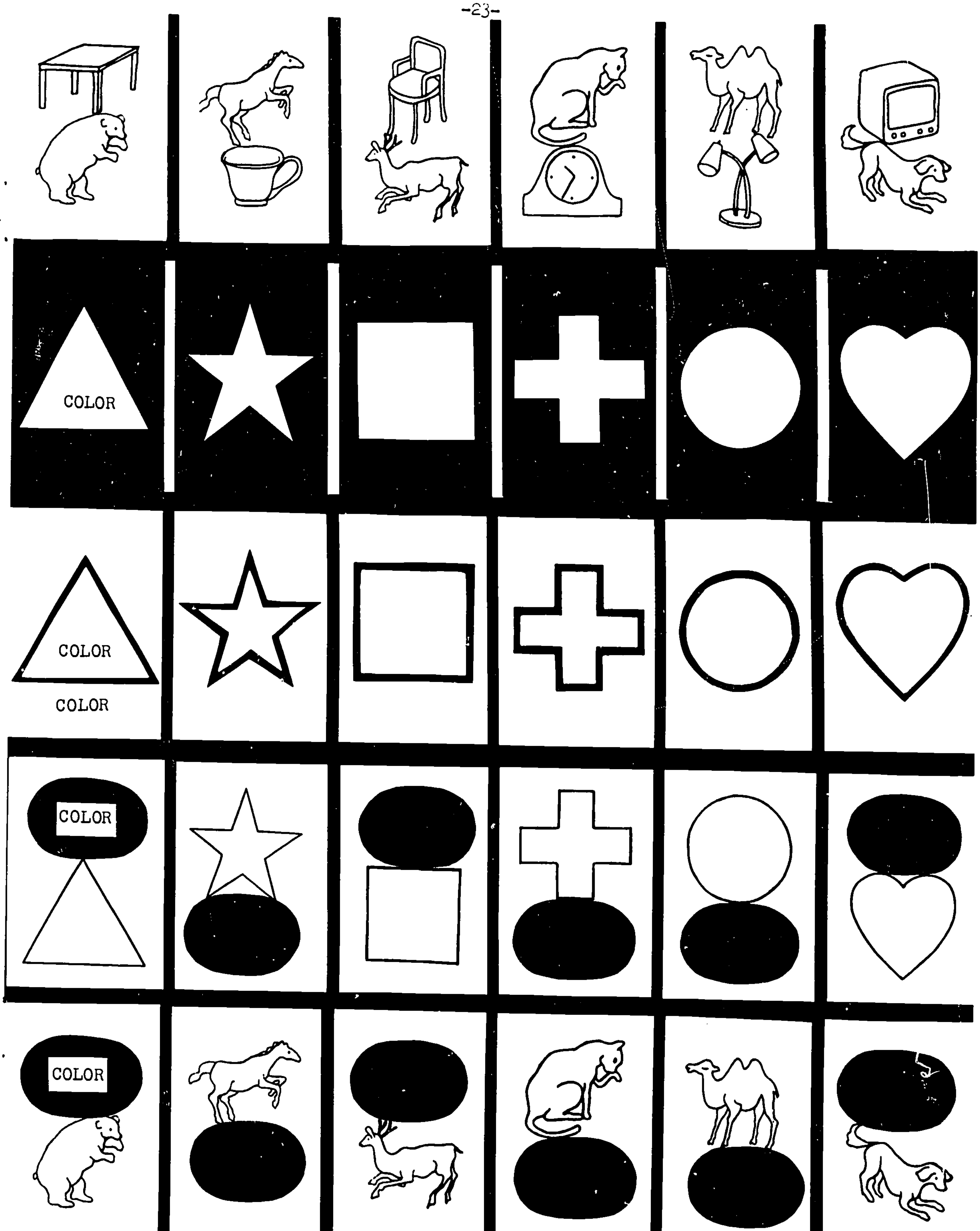

Figure 1