THE EFFECT OF AGE ON ACHROMATIC AND CHROMATIC DISCRIMINATIVE LEARNING

Thesis for the Degree of M. A.

MICHIGAN STATE UNIVERSITY

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1956

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By

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A THESIS

Submitted to the College of Science and Arts
Michigan State University of Agriculture and
Applied Science in partial fulfillment of
the requirements for the degree of

MASTER OF ARTS

Department of Psychology

1956

ACKNOWLEDGMENTS

This study was originally conceived under the direction of Dr. Allen D. Calvin, formerly of Michigan State University and now of Hollins College. Since Dr. Calvin's absence, Dr. Alfred G. Dietze has been the immediate advisor. The author is deeply indebted to both of these men for their encouragement, helpful criticism, and generous aid.

All data were collected at the Marble School, East Lansing. Sincere thanks go to Mr. Donald W. Bath, principal of Marble School, whose cooperation made this possible.

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INTRODUCTION

A number of investigators have studied the relative effects of different kinds of visual stimuli on discriminative learning. Research in this area with sub-human primates has shown, for example, that planometric and stereometric cues are equally effective (9), that horizontal and vertical cues are equally effective (9), and that problems with stimulus objects are easier than those with patterns (9, 10, 11, 12, 19). Also from several studies it has been established that color and form are more easily distinguished than size and number, although whether color is more facilitative than form or not is as yet unresolved (6, 7, 11, 12, 16, 17, 18, 19).

Calvin and his associates (4, 5) have recently offered evidence from work with children that is not in accord with what might be expected from the work with sub-human primates. From the various stimulus dimensions investigated, i.e., color, form, size, achromatic brightness, brightness within the same hue, and pattern vs. no pattern, they consistently found learning to be most difficult when the cue stimuli differed in color. In one of the studies (5) the color problem consisted of a blue vs. green discrimination and in the second (4) it consisted of a green vs. red discrimination. To account for this result it was suggested (5) that the children might be utilizing concepts which, while highly adaptive in the majority of situations, inhibit learning when the discrimination must be on the basis of color differences. Thus in a problem involving cues differing in size, the concepts "large" and "small" would facilitate learning, but in a problem involving cues differing in color, the concept "colored" would act as a handicap. Even though clearly different, as long as the cues were conceptualized as "colored" they would remain inseparable for purposes of solving the problem.

The following experiment was designed to extend the study of the relative difficulty of chromatic and achromatic discriminative learning by including children from the kindergarten through the fifth grade.

METHOD

Subjects: The Ss were 120 elementary school children, 24 chosen from each of five grade levels. Within each level, half of the Ss were tested on a black vs. white discrimination and half on a blue vs. green discrimination. This gave the following ten experimental groups: OA, kindergarten-achromatic; OC, kindergarten-chromatic; 1A, first grade-achromatic; 1C, first grade-chromatic; 2A, second grade-achromatic; 2C, second grade-chromatic; 3A, third grade-achromatic; 3C, third grade-chromatic; 4-5A, fourth & fifth grades-achromatic; 4-5C, fourth & fifth grades-chromatic. There were six boys and six girls in each group and the last two groups had as many fourth as fifth graders. Of the Ss who were tested on the blue vs. green discrimination half in each group had the blue card positive and half had the green card positive. A corresponding balance existed in the groups tested on the black vs. white discrimination.

Within the restrictions set by the experimental design the Ss were randomly assigned to the various groups. The problem for any S was pre-determined by E and unknown to the teachers who selected the children for testing.

Apparatus: The apparatus consisted of a platform 8" deep behind a vertical white cardboard screen. The screen was 22" wide and 28" high and could be raised and lowered by E. Two orange cups 3" in diameter at the top were placed upside down about 4" apart on the platform and at equal distances from S. A small metal charm was concealed under one of the cups and served as the reward. Stimulus cards were placed flat on the platform, one in front of each cup. The four cards were black, white, blue, and green and each was $2\frac{1}{2}$" x $3\frac{1}{2}$".[1] The apparatus was situated on a small table directly in front of S and concealed E from S except when the screen was in the raised position. Illumination from an overhead light eliminated shadows from the platform area.

Procedure: Upon entering the testing room S was seated comfortably at the table and given the following instructions:

> "We are going to play a little game. Behind this screen there are two cups and under one of them there is a toy. If you can guess which cup the toy is under, you can keep the toy."

The screen was then raised and the cups and stimulus

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1. Approximate Munsell values for the colored cards were 7.5 PB 3/10 and 2.5 G 5/8.

cards exposed to S. If they did not do so spontaneously, the Ss were instructed to choose one of the cups by pointing at it. No other form of response was accepted. When they had pointed, the chosen cup was raised. If the choice was correct, a toy was exposed and immediately handed to S. If the choice was incorrect, the raised cup revealed nothing and S was shown that the reward was under the other cup. The screen was then lowered and the reward and stimulus cards replaced for the next trial according to a pre-determined random order by Gellerman (8).

The criterion for learning was ten consecutive correct trials. If this was not met, the test was terminated at the first incorrect choice after trial 30. All non-solvers were arbitrarily given a score of 40.

After an S had completed a series of trials, the following questions were asked: "How could you tell which cup the toy was under? How were the cups different? Did you see the cards? What color were they?"

RESULTS

Table I shows median trials to criterion and the percentage of Ss in each group who solved their problem. No significant differences between grade levels were obtained for either the achromatic or the chromatic problem. When all Ss having the achromatic problem were compared with all Ss having the chromatic problem in terms of the number of Ss in each group who reached criterion, a Chi-square of 7.5 was obtained. This is significant beyond the .01 level.

From their answers to the questions asked after testing all Ss demonstrated ability to distinguish and name the colors on the cards correctly.

TABLE I

MEDIAN TRIALS TO CRITERION

Grade level	Trials		% solving	
	A	C	A	C
0	40	40	41.7	25
1	12	36.5	75	50
2	22	40	66.7	33.3
3	20.5	40	75	25
4-5	38	39.5	50	50
combined	21	40	61.7	36.7

DISCUSSION

A number of Ss in both the groups with the chromatic problem and the groups with the achromatic problem failed to reach the criterion. This suggests the possibility of factors common to both problems that are preventing the relatively rapid organization necessary for solution. Recent studies on both lower organisms (1, 2, 21) and children (3) indicate the importance of spatial relations in a two choice discriminative learning situation. They show that placing the differential cues close to each other may prompt a configural organization that inhibits isolation of the directionally orienting properties. For example, if the black card and the white card were organized as a single unit, each trial would be another presentation of a black-white configuration, or an achromatic configuration, and the ready separation of more useful elements, e.g., black-on-right and black-on-left, would be more difficult. The closer the cards were together the more difficult their separation would be. Other factors common to both problems, e.g., the identical forms of the cards and the continuity of the edges in their placement, may also function to inhibit learning.

Another result of this study was that the chromatic problem was significantly more difficult than the achromatic problem. This corroborates earlier work (4, 5) and lends support to the hypothesis put forth by Calvin and Clifford. They hypothesized that a dominant concept "colored" inhibited the differentiation of the stimulus cards necessary for learning.

Further evidence for such a concept is found in Koffka. He notes, "The Sterns report of their daughter that 'at the age of three years and two months Hilda called bright and dark things white and black; otherwise she named correctly only the colour red. But the accuracy of the word red was obviously quite accidental since all variegated colours were likewise called red.'[298] As Winch has noted, it often happens that variegated colours are distinguished from neutral tones by giving them all the same name, which indicates that all variegated colours have a common characteristic in contrast to the achromatic tones, and that this common factor must therefore be much more influential than any differences seen between the variegated colours themselves. " (15, p.285).

Werner (20) discusses the general kind of sensory organization proposed here and cites it as the early phase in development to a higher level of "categorical abstraction" where the individual can purposefully shift his point of view in grouping activity. At the earlier level properties of the stimulus objects themselves automatically force their organization and at the same time inhibit the perception of relations based on other properties.

The absolute degree to which the children were handicapped on the blue vs. green problem was not determined. Had more opportunity been provided the Ss who failed to solve may ultimately have done so. Actual inability of some of the Ss to perceive a difference between the colored cards is ruled out as all of the Ss without exception when questioned after testing differentiated and labeled the cards correctly.

With reference to experimental data Werner says that the level of categorical abstraction was never reached unaided before eight years of age and usually not until eleven to twelve years of age. He points out, however, that the evidence for growth of the abstraction process may vary with the experimental conditions. The lack of variation between age levels in the present study indicates that the type of abstraction observed is relatively stable from the kindergarten to the fifth grade. That this result is due to less motivation at the higher levels is unlikely. In the author's opinion, the number of toys received rather than their physical characteristics afforded the most incentive and interest in "who got the most" actually seemed to increase rather than decrease with age. The concept "colored" is, then, probably well established before school age. Indeed, Koffka places its establishment within the first year: "... during the first three-quarters of the child's first year of life no configurations of colour arise other than a primitive chromatic-achromatic distinction.." (15, p.284).

It is likely, then, that learning to discriminate and learn the names of colors develops at an early age from a conceptual dichotomy of achromatic-chromatic. Later in development the concept of achromatic becomes further dichotomized into white-black, light-dark, light-not light, or some similar framework that is easily placed along a simple linear continuum and readily assimilated by the child. The concept of chromatic or "colored", however, is not so easily broken down. Although continua are recognized as existing between say green and blue, the new colors emerge relatively isolated from the general framework of "colored". At no time is there an organization such as light-dark in the case of the concept "achromatic" that exists stronger than the superordinate "colored". Under more optimal conditions the concept of a single color, e.g., "blue", might predominate, or a relatedness might be seen between two separate colors, e.g., blue and green, but generally the condition is such as to favor the dominance of the general concept "colored" to the suppression of the more atomized subordinate concepts.

It is important to recognize that proposing the concept "colored" immediately implies a higher order cognitive framework apart from the primitive sensory organization found in lower organisms. This is due to the fact that the results of both the studies by Calvin and associates (4, 5) were contradictory to those of similar research on sub-human primates (7, 11, 12, 16, 17, 19). While color cues inhibited learning in children, monkeys learned most readily when the cues differed in color. If we may assume that monkeys operate cognitively on a lower level than first grade children, then these data must be due to something in children in addition to or superseding that which is inherent in monkeys. Other studies such as those by Hunter (13, 14) which showed conceptual transposition behavior in children and a lack of it in rats also seem to indicate that the process of conceptual organization in humans is qualitatively different from other organisms in the phylogenetic hierarchy.

SUMMARY

This study was designed to examine the relative participation of a previously hypothesized concept "colored" in solving a discrimination problem at successive levels of development. Children from the kindergarten through the fifth grade were tested either on a black vs. white problem or on a blue vs. green problem. Although no differences in performance were found between grade levels the chromatic problem was significantly more difficult than the achromatic problem. Implications of these results along with those of previous similar studies for both ontogenetic and phylogenetic comparisons were discussed.

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Date Due

Jul 31 '57			
Jul 31 '57			
Nov 22 '58			
NOV 2 5 1965			

Demco-293