THE EFFECT OF IRRELEVANT FORM CUES UPON LEARNING AND TRANSFER OF COLOR CONCEPTS IN YOUNG NORMAL CHILDREN

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ABSTRACT

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IN YOUNG NORMAL CHILDREN

By

Bruce Lowell Bachelder

The present study stemmed from efforts to improve the efficiency of teaching color concepts to retarded children. The behavior taught was a conditional discrimination in which the Ss learned to choose one of two colors depending upon which of two color names was spoken by E. Thus, when E said "red" a reward was found under the red discriminandum and when E said "blue" a reward was found under the blue discriminandum.

A stimulus-response analysis of this learning paradigm suggested that form cues would influence the development of the color concepts because S would be reinforced in the presence of both form and color cues. As a result the form cues should exert some control over S's responding. Three levels of form variability were compared in their effects on learning and transfer of color concepts.

Normal children, 3-4.5 years old served as Ss in a within-Ss design in which 24 'observations' under each of three conditions were made on each S (for a total of 72 observations of each S). Each observation was a conditional discrimination problem with six training trials (which used colored geometric forms) and one transfer trial (which used colored silhouettes of familiar objects). The E spoke color names on each trial to provide the conditional cue for correct responding. In the problems of condition I the form cues were the

same within a trial and between trials of each problem. In problems of condition II the form cues were identical within each trial but changed from trial to trial. In problems of condition III, form cues differed within trials and changed from trial to trial.

No main effects due to conditions were found. There was slight evidence of interactions between conditions and blocks of practice for training trials and transfer trials. The interaction of conditions with blocks of practice on training trials was such that the curves of the number of correct responses as a function of blocks of practice were positively accelerated in the case of conditions II and III but negatively accelerated in condition I. In addition, in the first block of practice the curves for conditions II and III are higher than the curve for condition I; in blocks 2 and 3, the curve for condition I is very slightly higher than the curves for conditions II and III; in the final block of practice the curves for conditions II and III are again above that of condition I.

The interaction of conditions with practice on transfer trials was such that transfer following conditions II and III was relatively constant throughout all training sessions while the transfer following condition I was at first below that of conditions II and III then rose above conditions II and III in the final block of practice.

It was concluded that for normal Ss with MAs about 3-4.5 years, the form cues had little effect upon learning and transfer of color concepts, although there was some evidence of interactions of conditions with practice for both training and transfer of the color concepts. This conclusion was not extended to retarded children for whom there was still some reason to feel that the form cues would be important.

A theoretical discussion of the conditional discrimination was presented. The interaction of conditions with practice on training trials was attributed to an error factor operating only in condition I. The interaction of conditions with practice on transfer trials was attributed to external inhibition of cue responses. A number of suggestions were made for improving the efficiency of teaching color concepts to retarded children.

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INTRODUCTION

The application of the data of learning experiments and of learning theory appears to have improved methods for training the severely and moderately retarded (IQ 20-50) to the extent that these individuals are now learning skills once felt to be well beyond their capabilities. These skills include subtle visual discriminations (Sidman and Stoddard, 1966), reading and learning simple qualitative and relational concepts (Denny, 1966 and Evans, 1968), and diligent classroom behavior (Bijou, Birnbrauer, Kidder, and Tague, 1967).

Initially, the present research was directed at studying the learning of color concepts by retarded children. Prior training attempts by the author suggested that severely retarded children may have more difficulty learning to respond appropriately to color names than to names of other qualities such as rough-smooth, large-small, and relational words such as up-down, and before-behind. Thus, in part, the present paper represents a stimulus-response analysis of the problem of learning colors. This analysis attempts to understand this difficulty and to suggest more efficient training methods. A pilot experiment on the problem used retarded children as Ss but proved so tedious that it was decided that normal children who did not know their colors would be better Ss, at least during the development of a new experimental paradigm. The choice of normal children also seemed appropriate because a variety of studies (see Denny, 1964) have shown that the performance of normal children on learning tasks is comparable to the performance of retardates of similar mental age.[1]

History of training retarded people

The approach to the training of the retarded that is taken in the present paper comes out of the learning theory tradition in psychology, as exemplified in the work of Skinner and Hull. As such, it emphasizes the training of behaviors, or responses. This approach can be contrasted with one that has its roots in British empiricist philosophy, as exemplified in the writings of John Locke. Locke asserted that all knowledge comes through experience, either through the senses or through reflection on sensory data. For the education of the retarded, this theory suggested an emphasis not on responses or behaviors directly but on the 'prior' senses or perceptions. As

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[1] The normal children were not intended to substitute for retarded children. Complete examination of the problem would include one group of retardates and two groups of normal children. One of the two normal groups would have mental ages (MA) comparable to the MAs of the retarded Ss, while the other normal group would be comparable to the retarded Ss in chronological ages (CA).

The use of two normal groups was suggested by Denny (1964) not only to provide developmental data, but to classify the deficits of retarded children into one of two types: the low IQ deficit or the low IQ-low MA deficit. If the retarded group performs below the equal-MA group, we can conclude that the deficit is a low IQ deficit, since the two groups differ only in IQ. If the retarded group performs below the equal-CA group, then the deficit is a low IQ-low MA deficit because the groups differ on both measures. Both normal control groups are logically necessary to discriminate the low IQ deficit from the low IQ-low MA deficit.

Denny considers the low IQ deficit to be of greater import for understanding retardation itself because the low IQ-low MA deficit is readily attributable to the retarded person's being at an early stage of intellectual development (as defined by IQ test scores). If, however, compared with normal children at an equivalent stage of intellectual development, retarded people are still deficient on certain types of tasks, then such evidence strongly suggests that these low IQ deficits are fundamental to retardation itself. Analysis of low IQ deficits may result in improved concepts of intelligence and mental age.

Kolstoe (1956) has suggested, modern educational practice has attempted to include both sensory and behavior training for the retarded, but the stress plainly has been on the former.

Itard

The first serious attempt to train a retarded person, undertaken by Jean Itard between 1800 and 1805, was based upon Locke's empiricist philosophy. Itard felt that mental retardation resulted from insufficient sensory stimulation. He attempted to test this idea by curing the famed "wild boy of Aveyron", a boy discovered living 'wild' near Aveyron, France, in 1799 (Itard, 1962). This boy was generally indolent, had poorly developed sensory discriminations and emotional responses, and ran wild through the fields whenever the opportunity presented itself. The boy was observed to lift potatoes from boiling water with no apparent response to the high temperature. Loud noises such as a gun shot did not cause him to start or run, yet he was able to respond to soft sounds such as the approach of friends. He formed a close emotional relationship with Itard's housekeeper, then with Itard, only after prolonged close social contact; but never adjusted normally to others.

By a variety of ingenious methods, Itard made marked improvements in the boy's auditory, tactual, visual, thermal, olfactory, and gustatory discriminations; yet after five years Itard gave the project up as a failure because the boy was still unable to adjust normally to society.

Seguin

Edouard Seguin (1812-1900), strongly influenced by the changes Itard had effected in the wild boy, continued to develop training methods based upon sensory training. He agreed with Itard that mental retardation stemmed from insufficient sensory stimulation, but where Itard assumed that the lack of stimulation resulted from insufficient contact with a stimulating environment, Seguin argued that the cause lay in damage to the central or peripheral nervous systems. Consequently, Seguin's training program consisted of bombarding the nervous system with strong and persistent stimulation which he felt would get through to the central nervous system and eventually cause it to function normally. He used a system of muscular exercise and sensory training fit to the individual needs of the child.

Montessori

Montessori (1870-1952) also believed that sensory training would cure mental retardation and had great success first with retarded, then with normal, children. Her chief contribution was a series of 26 "auto-educational" devices which the children used individually to develop all the senses except smell and taste.

The new emphasis on behavior training

About the turn of the century, educators began to question the utility of merely training the senses to the exclusion of practical social and vocational skills. Duncan (1943) advocated a teaching method in which academic subject matter is correlated with shop work, crafts, and home economics. Ingram (1960) suggested a similar approach in which academic subjects are taught in a unit of activities relevant to the life of the children. Kolstoe (1956) described this new influence as a "...radical switch from stimuli to response." He suggested that

It would appear that up until the age of about 10 or so,

> the major curricular emphasis should be on the systematic presentation of stimuli in a sense-training program. This emphasis should gradually change until youngsters at a junior high school level are involved in a response emphasis program. In this program general education provides the child the opportunity of increasing his intellectual efficiency up to the limits imposed by his nature, and specific behavior training insures the development of patterns of behavior of a socially acceptable nature. (Kolstoe, 1956, Page 4)

The dichotomy between behavior development and sensory development

The passage above is based upon a distinction between development of the intellect and development of specific behaviors. In this frame of reference, specific behavior training is justified only by the need to make the child socially acceptable. Following the same line of reasoning, the proper time for behavior training is after maximal development of intellectual ability by means of sense training. The distinction between sense training and behavior training is based, however, upon an untenable distinction between intellect and behavior. Kolstoe overlooks the fact that sense training consists of teaching specific behaviors. The stimulus-response learning theory approach to training the retarded recognizes that intellectual abilities are made up of specific behaviors and are developed through their training. Bruner (1960) has made a similar kind of point in his discussion of the distinction between "doing" and "understanding". According to Bruner, classic texts in problem solving draw a sharp distinction between "rote drill" and "understanding", a distinction Bruner feels is unclear. Bruner argues that understanding comes through drill, a view he finds supported by his discussions with mathematicians, who say that their understanding of mathematics came about through practice at computation.

It has been shown with normal and retarded children as well as with rats and monkeys that, after training on specific behaviors, subsequent learning of similar behaviors takes on a more sophisticated, that is insightful, character often attributed to the intellect. The procedures used in this type of learning study are all similar in that S learns many different problems of a type, one after another. Eventually, S begins to solve each completely new problem in a very short time, typically in one or two trials. This phenomenon of "learning to learn" is called learning set.

Learning set has been studied extensively by Harlow (1949, 1959). In his studies, Rhesus monkeys learned two-choice discrimination problems. The first problems typically required many trials to learn, but after learning hundreds of specific problems of this type, the monkeys solved each new problem (new objects) in a single trial.

House and Zeaman (1963) report results similar to Harlow's but in studies in which retardates served as Ss (MAs 44-96 mo., CAs 105-235 mo., and IQs 26-73). Their report covers five different studies, each of which presented S with a large number of short (three trials only) two-choice discrimination problems. The Ss attained from 60% to 80% correct choices on the second trial of these problems.

This very simple two-choice problem is not the only type of activity in which retardates show increasing ability to learn after learning simple behaviors. Denny (1966) has developed a training method by which severely retarded adolescents have been taught simple qualitative and relational concepts. These Ss showed the same increasing facility at learning new concepts as did the Ss of House and Zeaman's report. Denny estimated that as many as 18 months of diligent training might be needed to make significant improvement in the learning rate of some of the more severely retarded Ss, but he is confident that the rate would increase.

Examples of training programs

After reviewing the learning literature relevant to retardates, Denny (1964) concluded that he was optimistic about training the retarded. As suggested by the literature, he summarized the assets and deficits of retardates as follows: (1) they seem to be deficient in inhibiting a response once it is learned, (2) they seem to be poorer than normal children on complex learning even when matched on mental age, (3) they have a deficit in verbal learning, (4) they lack verbal control of motor behavior, (5) with practice they learn nearly as well as normal persons on motor tasks, (6) rote learning tasks are nearly as easy for retardates as for normal persons if familiar materials are used, (7) their retention seems quite adequate, (8) they can learn to use verbal mediators if specifically trained to do so.

Training a visual discrimination

Discrimination learning is a task on which retardates show a low IQ deficit which becomes more pronounced as the discriminanda are made more similar (Denny, 1964). Denny suggested that this difficulty might be understood in terms of the retardate's difficulty inhibiting wrong responses, a difficulty which suggests that training would be more effective if steps were taken to prevent wrong responses from ever occurring at all. One way to prevent errors is to start with a simple problem and 'fade' into the more difficult problem in a carefully planned progression. In this transition from problem to problem S can continue to respond on the basis of the easier problem, yet at the same time respond appropriately to the new problem.

Sidman and Stoddard (1966) used fading to teach a difficult visual discrimination between a circle and an ellipse to a profoundly retarded adult (IQ $<$ 20). The subject worked in a booth containing a response panel made of nine projection screens arranged in a 3x3 square. Circles and ellipses could be projected onto these screens, and the brightness of the backgrounds of each figure could vary from dark to bright. The first problem S had to learn was an easy brightness discrimination in which he always touched the one screen which was brightly lit. When this problem was well learned, circles, squares, and Xs were projected onto the bright screen so that when the S chose the bright screen he also chose the figure.

This discrimination was then faded, in 20 brightness increments, into a discrimination of 'screen with the figure' from equally bright 'screens without a figure'. The final fading sequences involved fading in the ellipses, accomplished by projecting barely visible ellipses on all the incorrect keys. Gradually, these were made more distinctive until the S was responding correctly to the circle without help from brightness or distinctiveness cues.

Brightness variations, form positions, timing, and response recordings were all automatic. So long as the S did not make errors he progressed step by step in a predetermined sequence, but when he erred, the equipment backed up one step from which the S could continue forward as before. Most errors were isolated events reflecting a lapse of attention, but at difficult transitions S oscillated between two levels, unable to choose correctly in the new stimulus situation. When this happened new steps were added so that the transition was easier, errors were eliminated, and progress was restored. Certain other areas of the program were so easy that steps could be removed without producing errors. After extensive revisions of this sort, a training sequence was achieved which taught the discrimination with a minimum of effort on the part of the teacher and the subject.

Teaching simple concepts

Simple concepts such as up-down, push-pull, in-out, over-under, rough-smooth, long-short, thick-thin, and simple reading have been taught to severely and profoundly retarded Ss by means of a training method developed by Denny (1966). The implications of Denny's "elicitation theory" are translated into practice by the use of a teaching machine called "Mudrafa" (MUltiple Differential Response and Feedback Apparatus, Figure 1) which aids in precise stimulus manipulation, assists in providing stimulus feedback relevant to the concept being learned, gives S immediate knowledge of results, and prevents errors. Since all responses are made by pushing a bar, training of non-verbal Ss is quite as easy as training verbal ones.

According to elicitation theory, when stimulus elements are consistently paired with a response, these stimulus elements will begin to elicit that response. Accordingly, during training Ss are induced to give particular responses in the presence of well controlled stimulus conditions. Careful analysis of the stimulus is made so that only relevant cues will be paired consistently with the response. All irrelevant cues must be varied often so that they do not compete with the correct stimulus. Since the Ss learn concepts, words are part of the stimulus complex. In teaching up-down, for example, E says "go up", and prompts S to move the response handle upward.

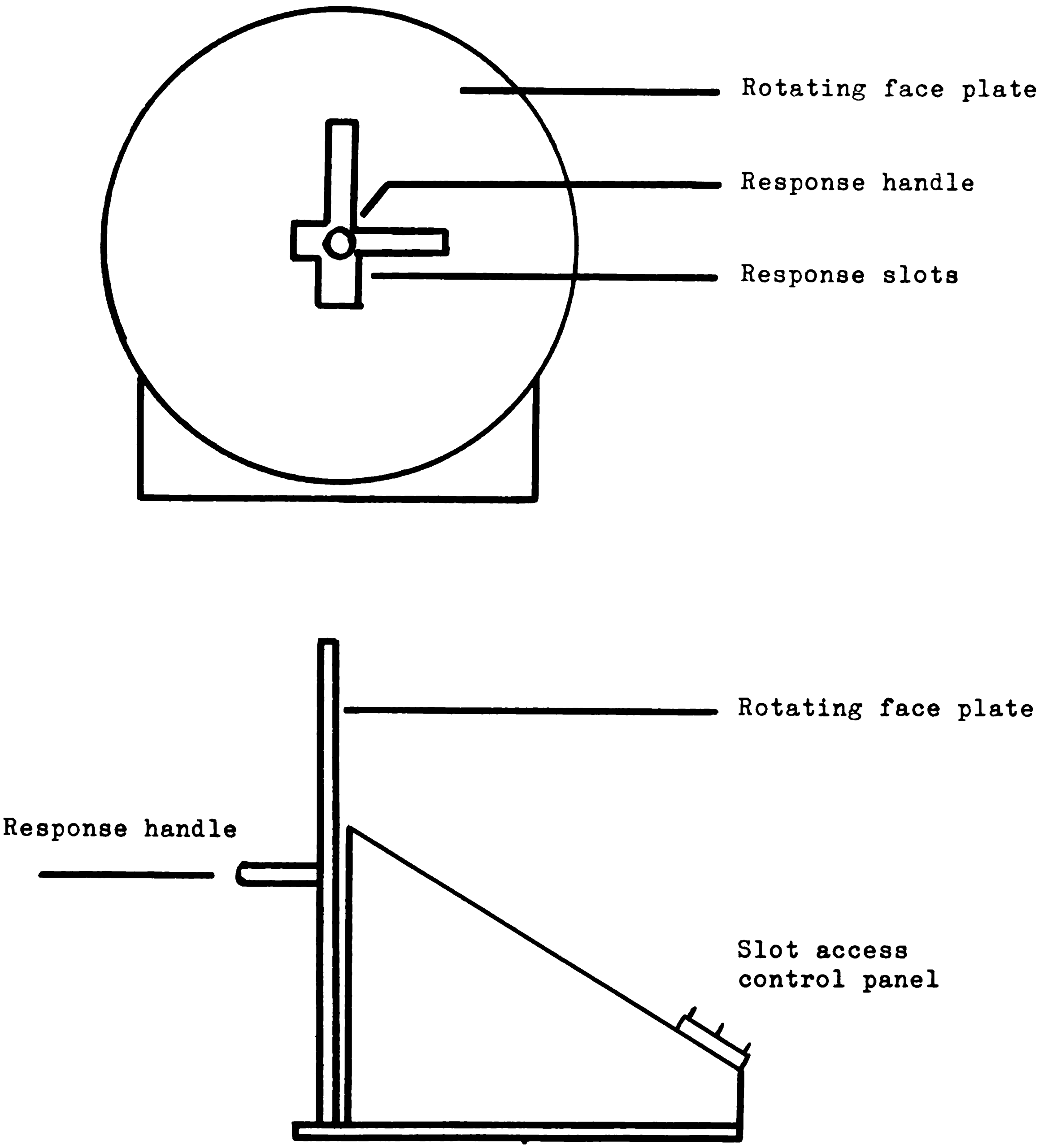


Figure 1. Mudrafa.

Prompting of the desired response may be as simple as pointing out the direction in which the handle should be pushed or as complex as telling the S what cues to look for. Denny suggests a systematic progression from simple prompts to complex verbal prompts which make use of previously learned concepts, for example, "it's the big one". By this means early training becomes very important to success, and continued practice on earlier concepts helps to ensure their retention. As prompting becomes very complex, S approaches the point at which he is learning in a way which is similar to ordinary classroom procedures where concepts are 'explained' and responding is highly verbal.

The basic components of Mudrafa are the rotating face plate, the response handle, the response slots, the slot access control panel, and the knowledge of results (KR) light in the handle (Figure 1). The face plate rotates in a complete circle so that each slot can be in each of the four positions for several trials during each training session. By this means the slot cues are made irrelevant. The response handle will move into each of the four slots so that with the bare faceplate S can learn the concepts of up-down, right-left, thick-thin, and long-short. Most training is done with stimulus materials placed upon the face plate so that the S selects one of as many as four pictures placed at the end of the slots. Knowledge of results is given by lighting the bulb in the end of the response handle. Each response slot is a different width and length so that thick-thin, wide-narrow, and long-short may be taught without other stimulus materials. Each slot gives differential feedback relative to the concept it teaches. The long slot requires a long push and a short slot only a short push. In the wide slot the handle can move freely from side to side within the slot, in contrast to the narrow slot which is just wide enough to accept the handle. Each slot can also be used in visual and verbal prompting, for example, "the long one, or the fat one", cueing S to the correct slot. The slot-access-control-panel allows E to control errors by blocking any combination of incorrect slots so that S cannot push the handle into them. The S cannot tell that a slot is blocked unless he tries it. In early stages of concept development, all slots but the correct one can be closed so that S finds the correct one easily. Later, when S is skilled at responding to prompts and can inhibit unrewarded responses, all slots can be opened and errors allowed.

The use of the slots for differential feedback is only one example of the machine's use for providing differential feedback. Denny suggests that such feedback be provided for all concepts taught. In teaching the concept of 'through', for example, brushes or tissue paper can be placed over the correct slot so that visual and tactual feedback, relevant to the concept 'through', occurs when the bar is pushed into the correct slot.

Teaching colors

The present study grew out of work on Denny's program and is as much concerned with the use of a spoken word as part of the stimulus situation as in form manipulation during color learning. Knowing colors can be operationally defined in terms of these specific behaviors: choosing a color sample in response to the color name, saying the color name in response to a color sample, generalization of these responses to similar hues, discrimination of several hues, and accomplishing all these behaviors despite variations of context, form, and size of the colored items. Choosing a color sample in response to a color name was the behavior taught in this study.

If retarded people do not learn this skill readily, it may be due simply to a slower rate of association of stimuli and response in which case only extra training time need be invested. Pilot work suggested, however, that severely retarded adolescents have relatively more difficulty with this color task than with simple concepts and simple reading. This difficulty could stem from misdirected attention. If Ss associated color names with form cues instead of, or in addition to, color cues, responding would be inaccurate. If such were the case, the retarded person's poor ability to inhibit responses would make learning even slower because of the added difficulty of giving up the incorrect response. The role of form cues during training and transfer of skill in choosing colors is the topic of this paper. Three levels of form manipulation were compared in their effects upon learning and transfer of color concepts.

METHOD

Apparatus

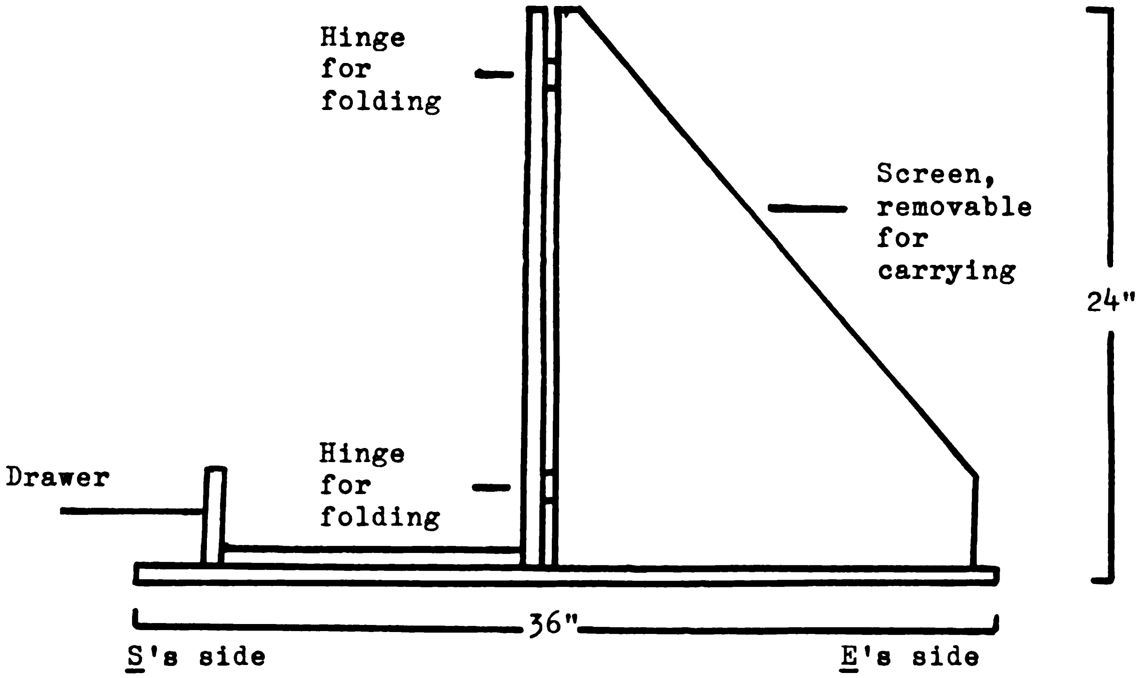
The apparatus was a Wisconsin General Test Apparatus (WGTA) modified for portability (Figure 2). The equipment could be rapidly assembled and disassembled and carried by a nylon strap. A vertical screen prevented S from seeing E, yet E could easily observe S's choice through the opening in which the drawer moved. Between trials the drawer was pulled to E's side and the vertical end of the drawer blocked S's view of the stimulus materials. When the new discriminanda were in place, the drawer slid easily to the other side for S's choice.

Discriminanda

Pictures. Two color photographs, $5\frac{1}{4}$ x $3\frac{1}{2}$ inches, of a leopard and an elephant were cut from a child's book of animals (Haas, 1965).

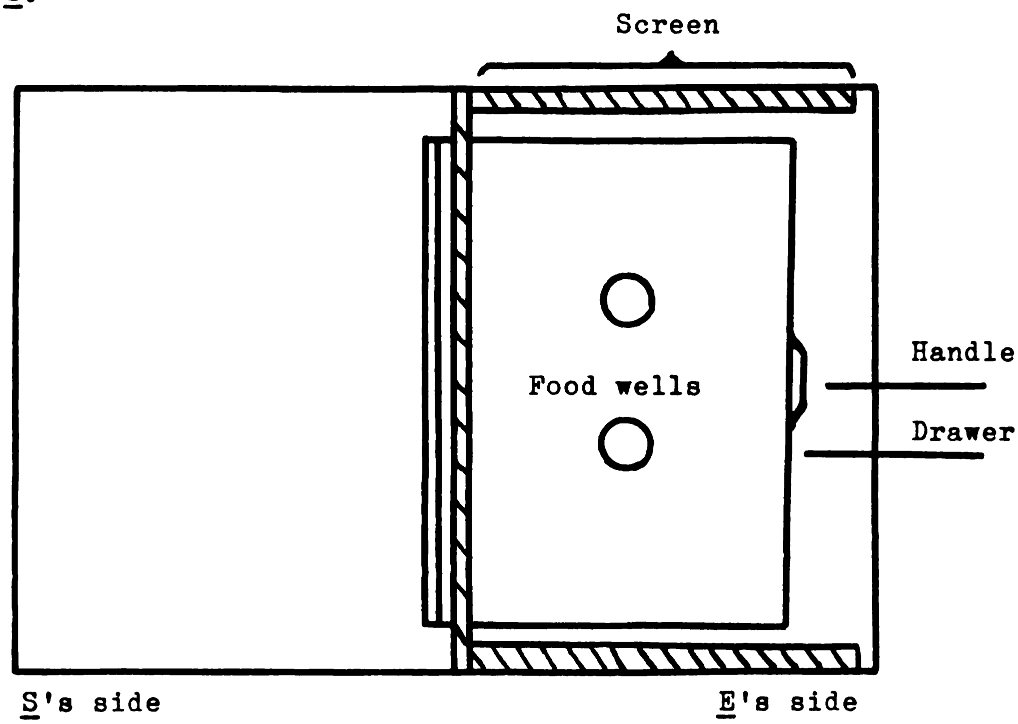
Geometric forms. Six geometric forms were cut from red, blue, green, and yellow construction paper. The colors of the papers closely approximated the Munsell (1929) numbers R 4/12, B 7/3, G 6/5, and Y 8/8. The forms were: 1) circles, 2 inches in diameter, 2) squares, 1-3/4 inches on a side, 3) equilateral triangles, 2 inches on a side, 4) pommée crosses, 1/2 inch wide, with arms 2 inches long, 5) diamonds with axes of 2 inches and 1-1/2 inches, and 6) stars which fit tightly within a 2 inch square.

Complex familiar forms. The complex forms were silhouettes of objects likely to be familiar to young children. Each was cut from each of the four colors as had been used in the construction of the geometric forms. Each form was drawn to fit closely within the area of a 2-inch square. All 24 such forms are reproduced in actual size in Figure 3 and listed in Table 1.



The sliding drawer has been pushed toward S.

Side view



The sliding drawer has been pulled toward E.

Top view

Figure 2. The portable Wisconsin general test apparatus.

Table 1. The complex forms

1. Heart	7. Tree	13. Christmas tree	19. Light bulb
2. Dress	8. Elephant	14. Sock	20. Apple
3. Cup	9. Teddy Bear	15. Shoe	21. Guitar
4. Ice Cream Cone	10. Santa Claus	16. Lamp	22. Snowman
5. Fish	11. Leaf	17. Truck	23. Flower
6. Head of a horse	12. Key	18. Mitten	24. Head of a rabbit

Procedure

Each S was trained on two-choice discrimination problems in his own home. The WGTA was assembled on the living room floor. Both S and E sat on the floor. Often parents and sometimes children were present during training, but they sat on E's side of the apparatus. Their presence tended to be a slight distraction for most Ss, but only during the first session.

The E told S that he had a game in which S could find a lot of candy. The E then demonstrated the game by putting a piece of candy in one food well partially covered by one of the animal pictures. The E then presented the drawer to S and waited for S to take the candy. At times E had to coax S to respond either by saying, for example, "look, here's the candy," or by leading him to the food wells. As soon as S began responding rapidly these demonstrations were terminated and pretraining was started.

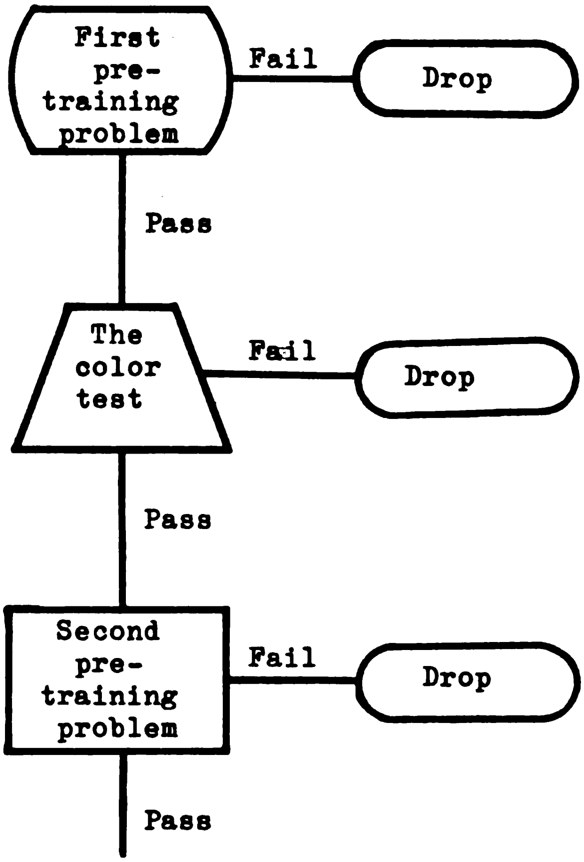
In all subsequent problems when S responded correctly, i.e., moved the positive discriminandum aside, he found a raisin, an M&M,

or a piece of sugared cereal in the food well of the WGTA. When S made an incorrect choice, E withdrew the drawer immediately so that S was allowed only one choice on each trial (the non-correction method). Some Ss ate the reward immediately, others saved some or all rewards in a bag.

Each S took an average of 15 sessions, each 15-30 minutes long, to complete two pretraining problems, a test of color and color-name association, and 12 sessions of experimental problems. The experimental problems were conditional discrimination problems in which each of two color cues was correct an equal number of times in each problem. The E loudly spoke the name of one of the two colors at the beginning of each trial to provide the cue for correct responding. For example, when E said "red", the red discriminandum was correct; and when E said "green", the green discriminandum was correct. Each step of the sequence of pretraining and experimental problems is described below and schematized in Figure 4.

Subjects

The Ss were normal children solicited by telephone calls to their parents or suggested by parents of children already in the study. All children were living in Michigan State University apartments for married students. Twenty-two children were found. All 22 were administered a test of color and color-name association as well as two pretraining problems which trained each child in both conditional and non-conditional two-choice discrimination paradigms. These screening problems are described in detail below. From this group of children, only those children were chosen as Ss who failed the color test but passed the pretraining problems. Six children, varying in age from 3



The experimental sessions. Each session had six problems.

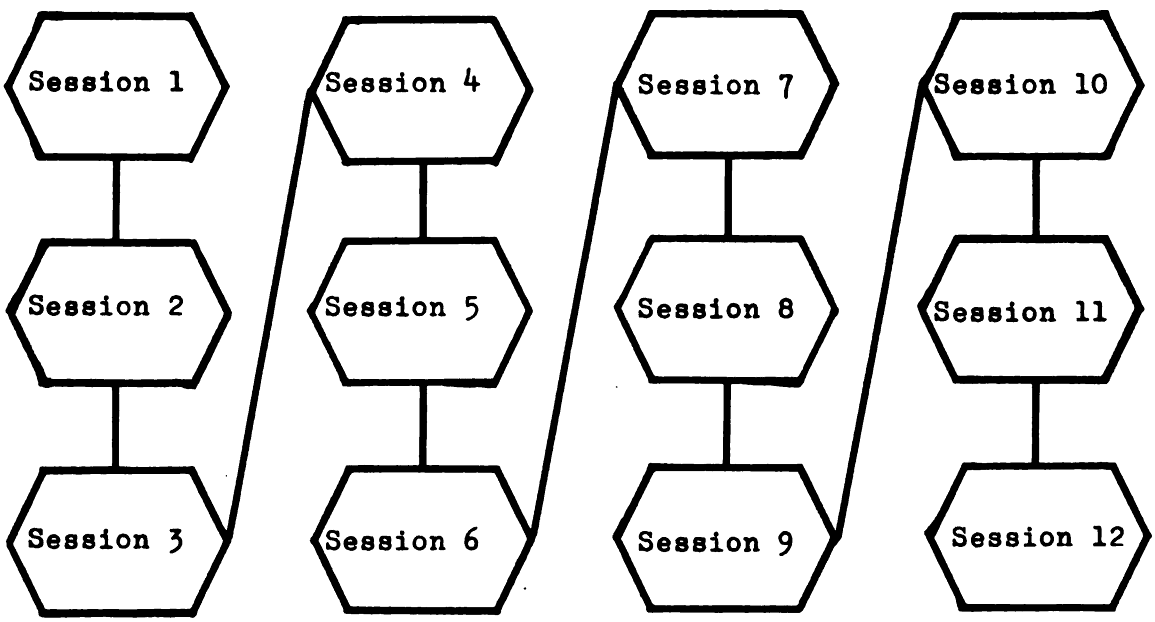


Figure 4. A flow-chart of S's progress through the screening and pretraining problems and experimental problems.

years to 4.5 years ($\bar{X}$ = 3.6 years) qualified.

The first pretraining problem, administered to all 22 potential Ss. Four children failed this problem. The first pretraining problem was a simple conditional discrimination problem in which the correct choice was dependent upon a word spoken by E on each trial. This problem served to train Ss to listen for the conditional cue, the spoken word, then to choose one of the discriminanda for reward. The pictures of the leopard and the elephant were the discriminanda and the words "leopard" and "elephant" were the conditional cues spoken by E as he pushed the drawer of the WGTA toward S. The position of the correct discriminandum varied according to a Gellerman series (Gellerman, 1933). The conditional cues were chosen randomly except that E spoke each word no more than three times consecutively. Training sessions, each 24 trials long, were repeated daily until S made seven consecutive correct responses or had completed three sessions. In the former case, S passed on to the color test; in the latter case, S was dropped from the study.

The color test, administered to the 18 children who successfully completed the first pretraining problem. Five children failed this test, that is, did not continue on to the final pretraining problem. Four knew their colors and one refused to cooperate further. Following successful completion of the first pretraining problem, the color test was administered to eliminate Ss who already knew their colors. The color test was a conditional, two-choice color discrimination problem with color words as the conditional cues. The complex familiar forms were the discriminanda. Each of the four color names (red, blue, green, and yellow) was called six times for a total of 24 trials. Each of the six possible pairs of colors appeared four times in a random sequence restricted so that a specific color appeared in a maximum of three successive trials and a specific color pair appeared in a maximum of two successive trials. Colors and position were selected so that left was correct as often as right.

The forms used on trials 1-12 of the color test were selected randomly from the pool of 24 complex familiar forms. In trials 1-12, then, twelve forms were positive, that is, correct and rewarded, and twelve forms were negative. In trials 13-24 the complex forms were selected randomly again except that previously positive forms were paired only with other previously positive forms and previously negative forms were paired only with other previously negative forms. This pairing of positive with positive and negative with negative prevented systematic transfer of choice based upon the previous positive or negative value of each form cue. To qualify for the final pretraining problem and for participation in the experimental sessions, Ss had to score fewer than 18/24 correct on this test. Calculated by binomial expansion, the probability of achieving 18 or more correct out of 24 by random responding is less than 1%. One color test was constructed and used for all Ss (Table 2).

The second pretraining problem, administered to the 13 children who passed the first pretraining problem and scored fewer than 18 out of 24 correct on the color test. Six children failed this problem leaving 7 qualified Ss. One of these later refused to cooperate and was dropped. The second pretraining problem served to orient the Ss toward color cues. This problem differed from the other problems (the first pretraining problem, the color test, and the experimental

Table 2. The color test.

Trial	Discriminanda Left	Discriminanda Right	The correct color
1	g lamp	y tree	y
2	b flower	r santa claus	b
3	r shoe	b leaf	r
4	g mitten	y guitar	y
5	y horse	b Christmas tree	y
6	r ice cream cone	g fish	r
7	b rabbit	r snowman	r
8	y elephant	b sock	y
9	y light bulb	g cup	g
10	g dress	b apple	b
11	b truck	y heart	b
12	r key	g bear	g
13	y bear	g ice cream cone	g
14	b snowman	r apple	b
15	g tree	b cup	g
16	y dress	r lamp	r
17	y Christmas tree	r sock	y
18	g santa claus	b heart	b
19	g truck	b elephant	g
20	r rabbit	y leaf	y
21	g flower	r horse	g
22	y key	b fish	b

Table 2 (cont'd.)

Trial	Discriminanda Left	Discriminanda Right	The correct color
23	g shoe	r guitar	r
24	r light bulb	y mitten	r

r = red, b = blue, y = yellow, g = green.

problems) in that the second pretraining problem was not a conditional discrimination. The E did not speak a word and S had to learn to select a red star consistently when presented with a red star and a green star. As in the first pretraining problem, sessions were 24 trials long and continued until S made seven consecutive correct responses or had completed three sessions. In the former case he began the experimental problems in his next session; in the latter case he was dropped from the study.

Experimental variables. Each of these 6 remaining Ss served in all conditions, receiving 24 each of three types of problems for a total of 72 problems in 12 experimental sessions. Each of these problems was 7 trials long. Trials 1-6 of each problem, the training trials, used the geometric forms while trial 7, a test of transfer, used the complex familiar forms. The three problem types differed with respect to the way form cues varied in the training trials (1-6) of each problem.

Type I. In type I problems the form cues of training trials did not differ within or between trials, for example, blue square versus red square on all six training trials of the problem. The form cue used in each type I problem was selected randomly without replacement from the pool of geometric forms. This meant that in successive type I problems all six form cues were used once before repetition.

Type II. In type II problems, form cues did not differ within a trial but varied from trial to trial, for example, red circle versus yellow circle on trial one, then red cross versus yellow cross on trial two and so on through six training trials. All six form cues were used in each type II problem. The sequence of form cues was random for each type II problem.

Type III. In type III problems the discriminanda on each trial differed in both form and color, for example, red circle versus green square on trial one, then red cross versus green star on trial two. All six form cues were paired with the two colors of the problem and appeared once in trials 1-6. The sequence of color and form cues was determined randomly as follows. The twelve discriminanda formed by the pairing of six geometric form cues and two color cues were shuffled, drawn two by two, and assigned in order to trial 1, trial 2, and so on through trial 6. The resulting random sequence was restricted, however, by eliminating pairs in which the form cues did not differ.

Trials 7, the transfer trials, were comparable for all problem types. Form cues were selected at random without replacement from the pool of complex familiar forms. Twelve problems used up all the available forms so that in the next twelve problems, just as in the color test, previously positive forms were paired only with previously positive forms. Throughout all experimental sessions a specific pair of forms was not repeated for a given S.

Randomization procedures. In each of the twelve experimental sessions S received 6 problems. Each problem taught one pair of colors selected from among the six possible pairs formed from red, blue, green, and yellow. Each color pair was combined with each condition (problem type). Three conditions combined with six color pairs formed 18 color-problem combinations (CPCs). For each S, the order of presentation of the 18 CPCs was random, with the following constraints: 1) a specific color appeared in no more than two consecutive problems;

2) two consecutive problems of one type was a maximum; 3) a particular CPC was not repeated until at least six other CPCs had intervened; 4) each 18-problem-block (3 days) comprised all 18 different CPCs. A block of problems, then, was made up of one each of the three problem types combined with each of the six possible color pairs so that in each block, color pair and problem type were completely crossed and balanced.

In the training trials (1-6) of a given problem, each color name was called three times. The sequence of color names was restricted so that the three calls of one color did not occur consecutively. Six-trial Gellerman series were used to determine position of correct choice and the sequence of color names called out. Several of these six-trial series were available, each of which was combined with every other; one series for position determination, one series for color name sequence determination. Some of these combinations resulted in completely confounded position and color cues, that is, one color was always on the same side. All of these confounded pairs were discarded, leaving a pool of 40 useful pairs. These pairs were selected randomly for every experimental problem.

The position of the correct color on transfer trials was determined independently of the sequence on training trials. Since a daily session had six problems with one transfer trial each, one of the six-trial series was selected at random for use each day. The color name called on trial seven was determined randomly except that within each color pair each color name was called an equal number of times in each block of three days.

On any one day each S completed just one third of a block of problems. This meant that unless specifically planned for, each condition and color pair would not be represented equally each day over the whole group. To balance these factors each day for the whole group of Ss, CPCs were assigned to groups of three Ss in such a way that each day these 'yoked' Ss completed all 18 CPCs. As a result of this procedure, days of practice could be analysed as a completely crossed and balanced factor. The assignment of the 18 CPCs to the three yoked Ss was done as follows. A sequence of CPCs was constructed for one S such that each of the three blocks of six problems (problems 1-6, 7-12, 13-18) could precede or follow any other block without violating sequence restrictions. Each of the three yoked Ss received the three blocks in different orders for a total of two repetitions of the 18 CPCs, making a total of 36 problems. This procedure was repeated using a new basic sequence and resulted in a total of 72 problems per S. This procedure is schematized in Table 3.

Table 3. Between subject balancing of conditions each day.

Sessions	Subjects			
	A	B	C	
1	1	2	3	
2	2	3	1	
3	3	1	2	CPC blocks (6 problems each)
4	2	3	1	by experimental sessions.
5	1	2	3	
6	3	1	2	

Blocks 1-3 include all 18 color-problem combinations (CPCs). Each S completed one block of six problems each session. These blocks of CPCs were sequenced so that each S received all 18 CPCs in the first three sessions, then received them again in a new order in the next three sessions. The three Ss as a group completed all 18 CPCs every experimental session so that an analysis by sessions was possible. A similar sequencing procedure was followed on sessions 7-12 using a new basic sequence of CPCs. (See the text for details.)

RESULTS

Color test. The mean score on the color test was 12.6 correct out of 24 trials (chance = 12 correct). The mean number of correct responses for learners and non-learners was 15.7 and 9.7 respectively. The score of 9.7 correct attained by the non-learners is somewhat lower than chance behavior and probably reflects an error of programming. If, on a given trial, S tended to choose the color which was correct on the previous trial, he would be wrong more often than right.

Each color was correct six times so that guessing would tend to produce about three correct choices of each color. Some Ss scored higher than chance on specific colors. Each of the learners scored 5 or 6 correct on one of the colors, and one S scored this high on two colors. In the group of non-learners, the highest score on one color was 4 and this occurred only once.

The experimental problems. Figure 5 shows the number of correct responses in each block of problems. The two curves show the performance of two subgroups of Ss, three Ss who learned and three Ss who did not learn.

The score assigned to each S for the various analyses was the number of correct responses. This score had to be corrected somewhat in certain instances because an error in sequencing resulted in unequal numbers of problems in the three conditions. Within a block of problems the difference in number of problems amounted to one or two problems. The correction procedure estimated each S's score had all problems occurred equally. If, for example, there were 7 trials of condition III but only 6 trials of conditions I and II, a percent correct score was computed for the deficient observations then multi-

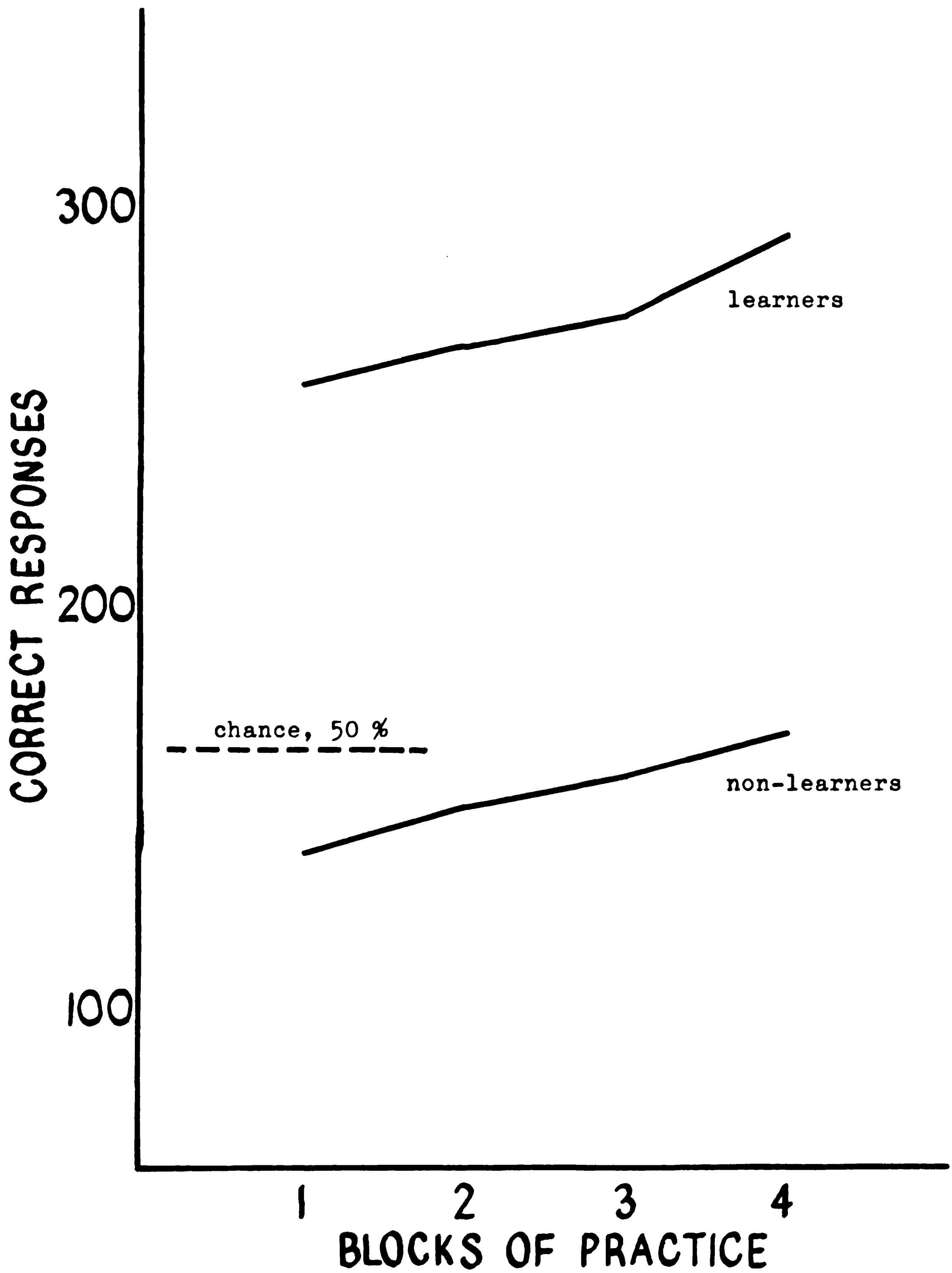


Figure 5. The effect of practice on the performance on training trials of learners and non-learners.

plied by seven. This procedure produced a score for seven trials which was equal, in terms of percent correct, to S's actual score based upon fewer trials.

The study, as originally designed, allowed analysis by sessions of training by sequencing the problems so that in each session three Ss as a group would complete all 18 CPCs. Since too few Ss learned the task, the analysis by sessions had to be replaced by an analysis by blocks of sessions. Each block comprised three sessions and included all 18 CPCs.

A blocks X conditions analysis of variance of the number correct on training trials (1-6) yielded only blocks significant (Figure 6 and Table 4). A similar analysis of variance on the number of correct responses on test trials (trial 7) yielded significant effects for blocks only (Figure 7 and Table 5).

Table 4. Analysis of variance of the effect of blocks of practice and conditions upon the number of correct responses on training trials.

Source of variance	SS	df	MS	F
Blocks	84.55	3	28.18	3.73 $p < .05$
Conditions	2.67	2	1.34	.18
Blocks x conditions	16.11	6	2.68	.35
Error	181.17	24	7.55	
Total	284.50	35		

Table 5. Analysis of variance of the effect of blocks of practice and conditions upon performance on test trials.

Source of variance	SS	df	MS	F	
Blocks	10.44	3	3.48	2.20	$.10 < p < .25$
Conditions	1.13	2	.56		
Blocks x conditions	5.66	6	.95		
Error	37.94	24	1.58		
Total	55.17	35			

Performance on transfer trials was compared with performance on training trials by a blocks X trials analysis of variance of the number of correct responses. Blocks only were significant (Figure 8 and Table 6). In this analysis the data for trials 1 and 2, 3 and 4, and 5 and 6 were combined because the curves before this grouping were very erratic. The comparison of trials 5 and 6 with trials 7 necessitated a correction of the trial 7 data to a base comparable to that of trials 5 and 6 combined. This correction was made by doubling the actual score S achieved over all trials 7.

The trials effect may have been statistically non-significant only because trials 1-6 were really not very different from each other so that, in comparison, the lower scores in transfer trials did not affect the variance estimates. This possibility suggested a direct comparison of the difference between performance on trials 5 and 6 with performance on trials 7 by an analysis of variance of these two trials alone. The pooled error term computed over all blocks was used in this analysis. The difference between the two means, however, was

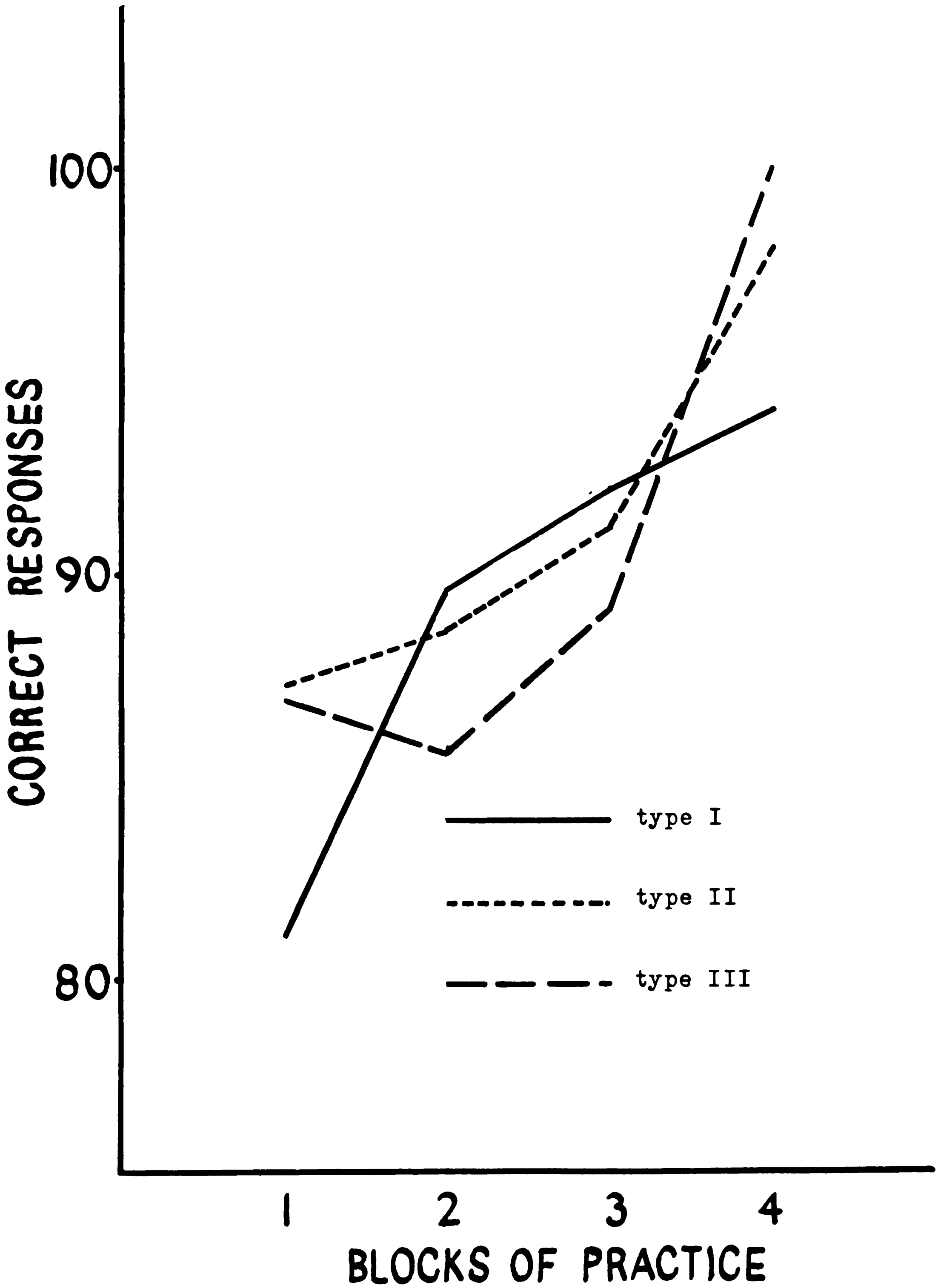


Figure 6. The effect of practice and conditions on the performance on training trials of learners.

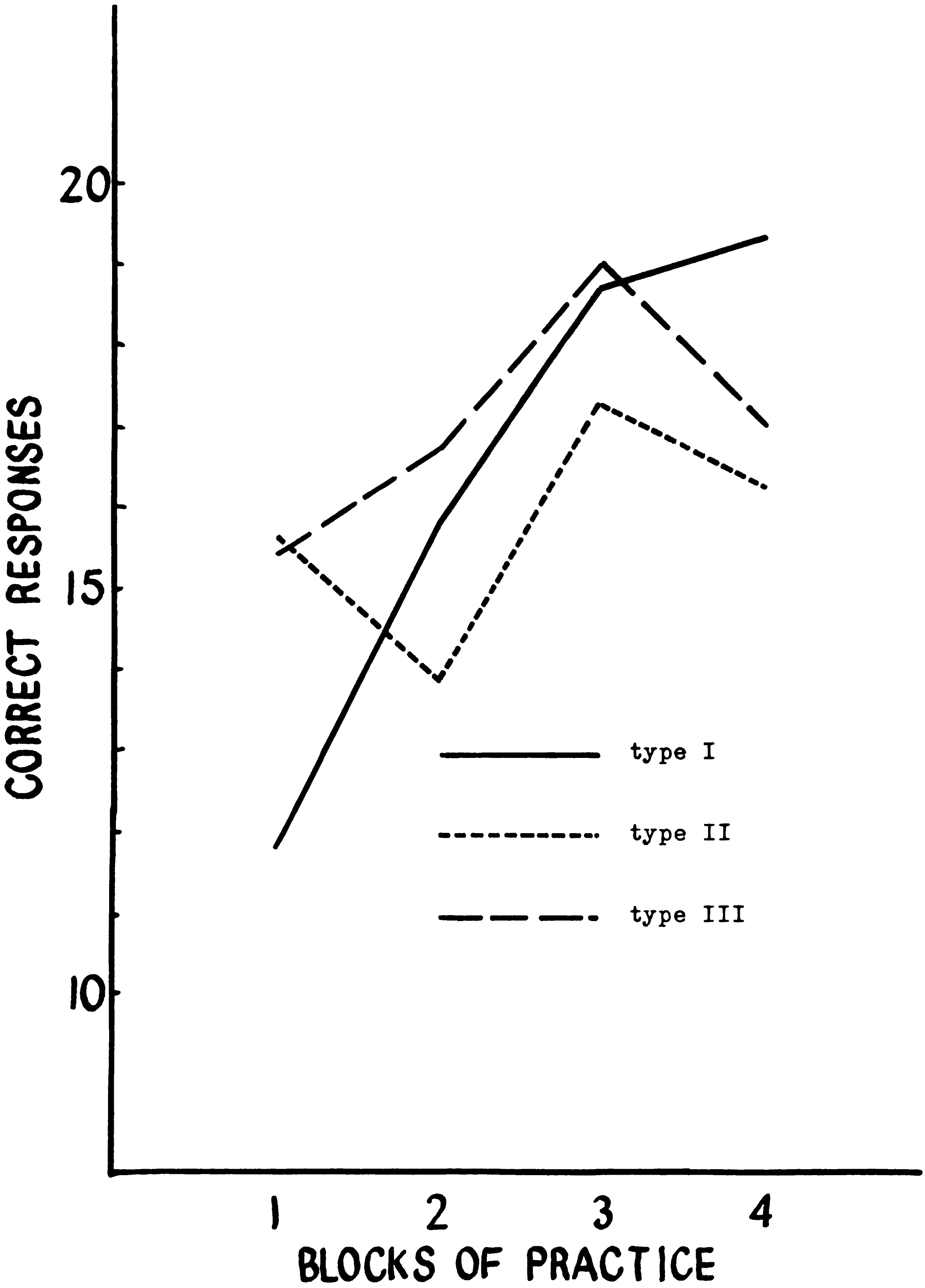


Figure 7. The effect of practice and conditions on the performance on test trials of learners.

still not significant (Table 7).

Table 6. Analysis of variance of the effect of blocks of practice and blocks of trials on the number of correct responses.

Source of variance	SS	df	MS	F	
Trial blocks	25.90	3	8.63	.86	
Blocks	128.73	3	42.91	4.28	$p < .025$
Blocks x trial blocks	38.52	9	4.28		
Error	320.67	32	10.02		
Total	513.82	47			

Table 7. Analysis of variance of the difference in number of correct responses given on trials 5-6 and trials 7.

Source of variance	SS	df	MS	F	
Trial blocks	20.16	1	20.16	2.01	$p = .20$
Error (pooled estimate, same value as in Table 6)	320.67	32	10.02		

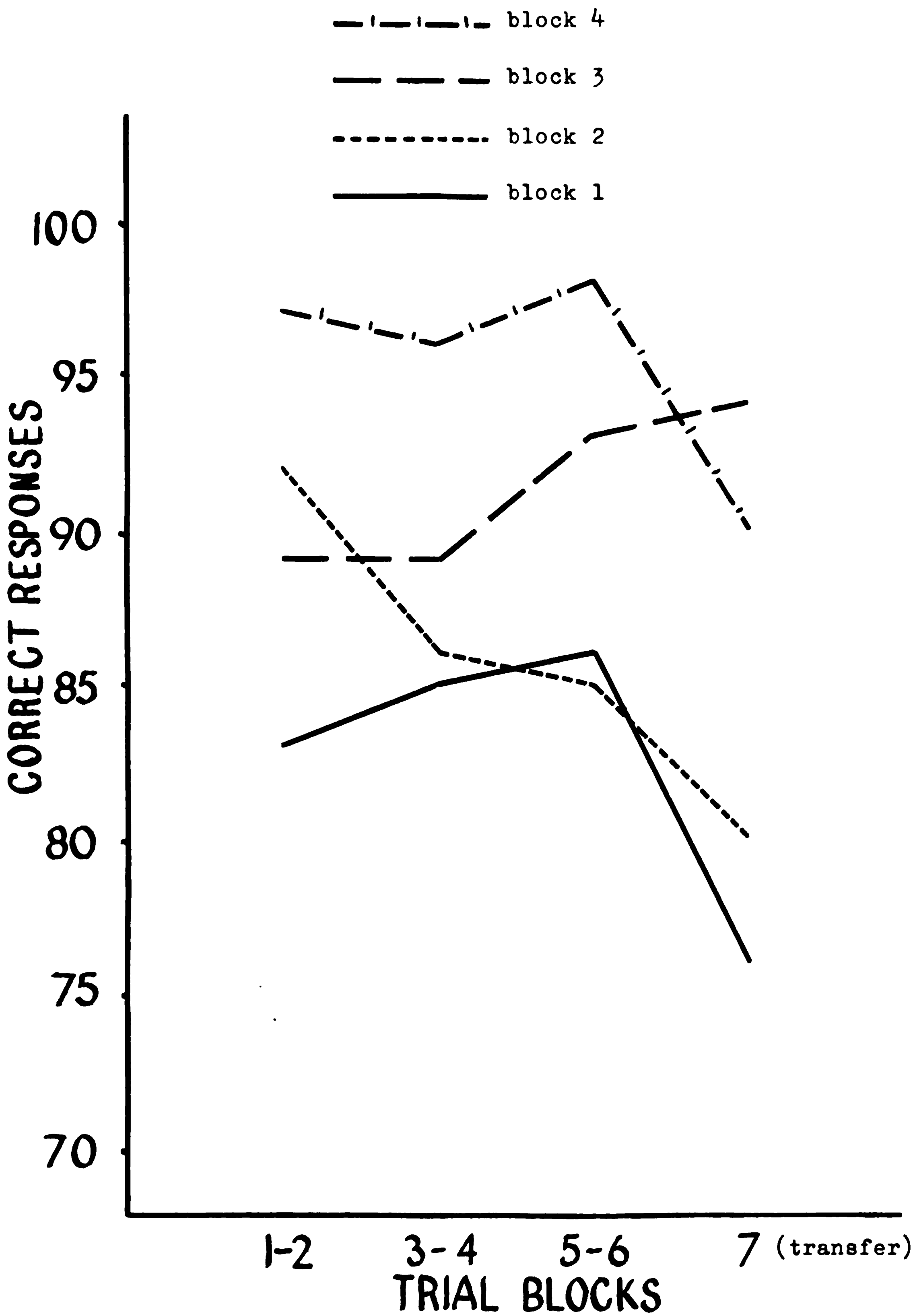


Figure 8. The effect of practice and trials on the performance of learners.

DISCUSSION

The color-choosing task as a learning paradigm presents two conceptual difficulties: how does the S solve the problem and what is the stimulus? According to a stimulus-response analysis, S cannot respond differentially in the learning situation unless there are two or more discriminable cue complexes which are differentially correlated with reinforcement. The S learns to respond one way to the first stimulus situation (S_1) and another way to S_2. In the present paradigm, all visual cues present at the time of choice have been made irrelevant, that is, any response based only upon the visual cues of color, form, or position cannot result in better than chance reinforcement. The S can solve the problem only by supplying cues himself. The discriminative stimulus which guides differential responding in this study must consist of the visual cue complex plus one of two or more cues added by S. This added cue is referred to in subsequent analysis as the 'cue response'. Analysis of the development and elicitation of this cue response is necessary for an understanding of the results of this study.

Figure 5 shows the number of correct responses in each block for the six Ss who finished all experimental problems. Three Ss learned the task, and three did not. Both learners and non-learners improved with training. The improvement of the learners' scores reflects increasing facility at solving the problems while the improvement of the non-learners' scores is an artifact of the design and does not reflect the development of appropriate responses. The performance of the non-learners starts well below chance in block one and rises steadily to chance performance in block four. A properly designed two-choice discrimination problem has the discriminanda sequenced in such a way that only one pattern of responding will result in scores which are significantly different from 50% correct (guessing on two items). The unusually low scores of the non-learners in block one suggests that certain consistent patterns of response resulted in very few rewarded trials. This idea was tested by applying a consistent pattern of response (a strategy) to one of the problem sequences actually given to one S. The strategy which was tested was a 'win, stay-lose, shift' strategy based upon color cues and went as follows. On the first trial of each problem one of the color cues was chosen randomly. If it was the correct cue, it was chosen again on the next trial, and if it was the wrong cue, the other color was selected on the next trial. Consistent application of this strategy produced a score of only 25-30% correct. This test was taken as good evidence that the non-learners actually employed this strategy in the early blocks. If it is true that non-learners consistently used this strategy early in training, then it is highly unlikely that the form cues had the effect on training that was originally hypothesized. Since Ss responded very consistently to color cues they could not have confused color and form cues. It seems clear that they had no difficulty finding the relevant dimension from the start of training.

Figure 8 shows that the learners improved very little within problems. This lack of improvement with repeated trials of the same problem probably results from there having been a limited number of trials in each problem. Each six-trial problem was essentially composed of a random combination of trials from two different problems. For example, in a problem which taught red and green, red was correct three times and green three times. It is not surprising that Ss found it difficult to solve two concurrent conditional discriminations whose trials were randomly interspersed.

Figure 8 shows that Ss tended to make fewer correct responses on transfer trials than on training trials although the effect was not statistically significant. This decrement on transfer trials may be attributed to the external inhibition of the cue response by the sudden change in the stimulus situation. The graph suggests that at the end of training the inhibitory effect is still strong. The difference between performance on trials 5-6 and trials 7 is rather constant in magnitude throughout the study with just one exception in block three. The reason for this exception is not clear. All Ss in all blocks except the third had equal or lower performance on transfer trials compared with trials 5 and 6. In block three two Ss improved on transfer trials.

There was little evidence that the scores of the learners were affected by conditions. The factor of conditions never approached significance either for training trials or for transfer trials. This is not surprising in view of the non-learners' data which indicated that even non-learners responded consistently to color cues. The learners also showed high levels of color and color-name association before training began as revealed by the high scores on the color test. These Ss already had cue responses appropriate to this task when they started training, and any effect on scores due to form manipulations was not strong enough to be detected.

There is some evidence that on transfer trials, conditions interacted with blocks of problems. The data suggesting this conclusion

(Figure 7) are not strong. Most variations in the curves represent group differences of only one or two correct responses. It will be assumed, however, for the purpose of discussion that there was an interaction such that early in training transfer was best in problem types II and III. Transfer in type I problems improved steadily until, in the final block, type I problems produced the highest level of transfer observed in the entire study. This interaction of conditions with blocks will be tentatively explained in terms of the disruptive effects of external inhibition of the cue response. The explanation will make use of an analogy between certain aspects of the learning and transfer tasks and one's reaction to the sudden noise of a door slamming shut. If you have not been warned of the coming slam, the sudden noise has a strong disturbing effect upon on-going behavior (external inhibition). If you are warned, however, there may be no disturbance of behavior at all. Similarly, in this study, if the decrement on transfer trials results from the sudden change in the stimulus situation, any cues which may serve to 'warn' S of the coming change in stimulus conditions should minimize the external inhibition and improve transfer performance. Such a warning cue is available in type I problems in the form of a pair of identical form cues on each trial preceding the test trial. Form cues in problem types II and III change continually and as a result can gain only minimal warning value compared with the unchanging form cues in type I problems. The low level of transfer in type I problems in block one can be explained similarly. Since changes occur on every trial of problem types II and III, the transfer trial is more of a change in type I problems than it is in type II and III problems. Early in training the form cues in type I problems have not gained any warning effect so that without the warning, external inhibition of the cue response would be quite strong. If this analysis is accurate, we should expect that retarded Ss would not show as strong an interaction of conditions with blocks. This conclusion follows because, according to the explanation above, high levels of transfer depend upon development of an internal inhibition of strong external inhibition. According to Denny's review of learning in retarded Ss (1964), retardates are consistently deficient in the ability to inhibit responses.

Suggestions for Training

Since S must make a cue response to solve this type of problem, the first step in training Ss to choose colors should be the development of a reliable cue response. A very appropriate training sequence might begin by teaching the S to repeat the color words spoken by the instructor before any attempt is made to introduce the choice response. Speaking the color name is not the only form the cue response may take, however. The effectiveness of word training should be compared with the effectiveness of training in color matching. The color matching situation is not unlike the color choosing situation in that color matching also requires that S produce a cue response closely related to the colors. The color matching task is analogous to the conditional discrimination used in this study. In the color matching task, S is presented with a color sample, a procedure which exactly parallels the use of the spoken word in this study. The color sample presented to S is a conditional cue which assumes control of S's subsequent choice of color samples. A cue response is implied in this situation for the same reason it was implied by the paradigm used in this study. There is little reason to predict the superiority of either color matching or color name learning as pretraining methods.

The data of this study strongly suggest that normal Ss learn color concepts without difficulties due to the form cues of the discriminanda. The data also suggest, however, that early in training form variability may facilitate transfer (transfer performance in block one was higher in problem types II and III). Training programs might be improved by manipulating form cues early in training but later, as S begins to respond appropriately, training and transfer are likely to be more convenient and at least as effective if form cues do not vary every trial.

These training suggestions may be restated in the language of attention theory. When form cues are varied regularly and are not available for consistent differential choice as in problem types II and III, S's attention will be directed to the color dimension. Such direction of attention is most important early in training; when S begins to respond correctly, we can be sure he is attending to the color dimension and the form manipulations become unnecessary. Severely retarded Ss are particularly likely to benefit from conditions which direct their attention to the relevant dimension. In the present study, the color word itself directed the attention of the normal children. Much stronger conditions probably would be needed for severely retarded children.

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