RETARDATE DISCRIMINATION LEARNING WITH CUE CHANGES IN RELEVANT AND IRRELEVANT DIMENSIONS

By

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CHAPTER I

INTRODUCTION

Within the past 15 years numerous theories of discrimination learning have been proposed, (e.g., Atkinson, 1958; Bush and Mosteller, 1951; Estes, 1959; Restle, 1955; and Zeaman and House, 1963). These theories have all attempted to make quantitative predictions of discrimination learning. All the theories, with the exception of one, assume that relevant stimuli are sampled on every trial. Zeaman and House (1963) propose that relevant stimulus dimensions are sampled only after the subject has learned to attend to them. In this theory, a subject must learn a chain of two responses; (1) attending to the relevant dimension and (2) making an instrumental response to the cues of the relevant dimension.

Although these theories do not agree on the discrimination learning process, all recognize the importance of cue change in the discriminative situation. Restle, in a series of informative studies (Restle, 1955; 1959; 1962; and Bourne and Restle, 1959), has demonstrated that discrimination learning performance improves with the increase in relevant dimensions and decreases in efficiency when the number of irrelevant dimensions is increased. Other researchers, (House and Zeaman, 1959; 1960; 1962; 1963; Zeaman and House, 1963), have been concerned with transfer operations which alter the attentional properties of the two choice discrimination situation and hopefully accelerate learning.

It is important to note that even though close scrutiny has been given to the issue of cue change, there remain certain cue transfer operations which are of theoretical interest which have not been investigated. One transfer operation which is as important as cue change per se is change in the distance between cues. Stimulus manipulation of this type involves stimulus generalization, an area of investigation which has been minimized by one theory of discrimination. Another operation is change only in the level of an irrelevant dimension without actually producing a new irrelevant stimulus.

Purpose of the Study

In the Attention Theory of Zeaman and House (1963) only scant consideration has been given to the problem of generalization. The problem has been minimized by using highly discriminable stimuli. However, Zeaman and House do maintain that if cues closer together on some continuum are chosen, they would expect the traditional finding that speed of discrimination learning is inversely related to the stimulus distance between discriminanda. To demonstrate this Shepp and Zeaman (1963) sought to determine if differences in learning exist between easy, medium and hard discriminations of size and brightness. In their study, learning curves showed wide performance differences among the conditions. In the easy condition (large physical differences between positive and negative cues) learning was most efficient. The hard discrimination (small cue difference) yielded the least efficient learning and the medium condition fell mid-way between the easy and hard conditions.

The results of the Shepp and Zeaman study support the assumption made in Attention Theory that the probability of attending to the relevant dimension at the start of training, $Po_{(1,0)}$, is directly related to the difference between the positive and negative cues. Thus discrimination learning can be deduced to be a direct function of physical cue difference.

A further investigation is suggested from the results obtained by Shepp and Zeaman. Since these researchers only employed subjects in easy, medium or hard tasks with no transfer condition to investigate the effects of shifting from an easy to a hard task or vice versa, the question is asked: What would the theory predict in shifting from an easy to a hard problem? If it is the case that initial Po is a function of cue difference, does cue difference affect Po once the problem is learned?

Theory, to be consistent, would state that if the probability of attending to the relevant dimension, Po, is high (i.e., 1.0), then transferring from an easy to a hard problem or vice versa should not cause a differential rate in performance.

In this study transfer will be studied in the size dimension. Stimuli of an easy and of a medium discriminability will be employed, since Shepp and Zeaman (1963) found that too few of their subjects in the hard discrimination condition achieved criterion to give stability to their backward performance curves. Therefore, it was decided that to get recordable data, easy and medium difficult conditions would be best, although for simplicity the medium difficult condition has been labeled as the "hard" condition for the purposes of this study.

In another theory of discrimination learning, Restle (1955) has assumed that constant irrelevant cues are "adapted out" of the discriminatory situation and do not control discriminative responding. Zeaman, Thaller and House (1964) in a study employing the 3-trial method demonstrated that color-form problems with a constant irrelevant dimension were associated with higher rates of performance than were problems with a variable irrelevant dimension. These investigators attribute this difference to the greater number of relevant dimensions (i.e., color-form compounds) which are produced by a constant irrelevant condition, rather than simply to the fact that there is an additional irrelevant dimension operating in the variable irrelevant condition which is Restle's contention.

Hence, the answer sought in the second part of the present study was whether a gross change in the level of a constant irrelevant dimension without actually changing the irrelevant dimension would result in a differential level of performance. If a constant irrelevant dimension is nonfunctional as Restle's theory assumes, no change in performance would be expected. However, if constant irrelevant dimensions combine with relevant dimensions to form compound cues yielding additional relevant dimensions as demonstrated by House and Zeaman (1963) and Zeaman, Thaller and House (1964), and if these compound cues are broken up by a change in the level of the irrelevant dimension, a performance decrement may be expected.

To test for this, color relevant problems were used. Changes occurred in the level of saturation of both the positive and negative cues. In all problems the positive cue maintained its same value after the shift in the level of the irrelevant dimension (i.e., saturation).

A modification of the 3-trial method of discrimination learning (House and Zeaman, 1963) was decided upon. In this method each subject serves as his own control by appearing many times in each condition of the experiment. This experimental technique was adapted from a combination of Estes' (1960) miniature experiment and Harlow's (1959) learning set method. In their own research, House and Zeaman have found the 3-trial method to be extremely useful in studying many conditions, since a limited number of subjects can be given an almost unlimited number of problems.

An important aspect of the 3-trial method is that the Ss are pretrained to attend to the relevant dimension with tendencies to respond to irrelevant cues or other extraneous factors largely extinguished. Therefore, for the purposes of this study, it was assumed that the Po of attending to the relevant dimension was at unity at the conclusion of pretraining.

CHAPTER II

METHOD

Subjects

Fifteen retardate subjects were selected from the Hissom Memorial Center, Sand Springs, Oklahoma, within the MA range of 5 to 9 years and from a population of subjects who had had successful previous experience with the visual discrimination procedure. Mean MA was 81 months (range: 70-104), mean IQ was 62 (range: 46-74), and mean CA was 155 months (range: 104-194).

Apparatus and Stimuli

The apparatus consisted of an adaptation of the modified Wisconsin General Test Apparatus used by Zeaman and House (1963). The apparatus had an 18" by 30" wooden base with two circular food wells 2" in diameter centered 10 inches apart. An opaque cloth screen 25" by 30" could be raised (11") and lowered by E in order that the food wells could be concealed while E arranged the stimuli to be presented on the following trial.

Stimuli consisted of pattern forms of varying sizes or colors mounted on a 3.5 in. by 3.5 in. black wedge base when presented to the S. Specifically, size stimuli consisted of patterns of a constant form (square) and of a constant color (black) and were of four varied sizes: large (36 sq. cm.), medium large (20.25 sq. cm.), medium small (12.25 sq. cm.) and small (4 sq. cm.). Color stimuli consisted of patterns of a constant form (circle) and of a constant diameter (6 cm.) and were of four varied colors (yellow, green, red, and blue). Two stimuli of each color, varying in degree of saturation were employed. This allowed for a total of eight color stimuli.

Stimuli were constructed from Zip-a-Tone color sheets and were mounted on a 3.5 in. by 3.5 in. white poster board base.

Procedure

Two stages of procedure were utilized: (a) pretraining and (b) experiment proper. Before beginning the experiment (b), each _S_ was required to pass a series of pretraining stages. During stage one, _S_s were given a problem with two 3-dimensional objects differing in size with color and form held constant, and a problem with two 3-dimensional objects but differing in color with size and form constant. A counterbalancing sequence was used so that half of the _S_s received the object-size problem first followed by the object-color problem, while the other half of the _S_s received the problems in reversed order. These object problems were presented for 25 trials a day to a 20/25 criterion. In the second stage of pretraining _S_s learned both a pattern problem differing in size with color and form constant, and a pattern problem differing in color with size and form constant. A counterbalancing sequence was again employed. These pattern problems continued for 25 trials per day to a 20/25 correct criterion. It was decided that Ss who could not meet criterion on any problem in either stage of pretraining after 5 training days would be dropped from the experiment. All Ss successfully achieved criterion in both stages of (a).

After completion of pretraining Ss began the experiment (b). Before each daily experimental session each S was presented a series of warm-up trials randomly varied for size and color. Stimuli used for the warm-up trials always differed from the testing stimuli. Trials continued until 6 successive correct responses were made or for a maximum of 25 trials. Those Ss failing to reach the 6-in-a-row criterion were not run on the daily experimental session, but continued on the same warm-up problem before the next session. Three successive days of failure on the warm-up problem was set as the criterion for dropping a S from the experiment. No S was dropped from the experiment.

During the testing session each S was given 4 4-trial size problems and 4 4-trial color problems per day for a total of 24 days. Size problems consisted of presenting the S with either an "easy" discriminable pair of stimuli for two trials and on the 3rd and 4th trials transferring to a "hard" discriminable set of stimuli, or vice versa. Thus during each daily experimental session, S received two size problems of easy-to-hard and two of a hard-to-easy discriminability.

In order to control for transpositional effects in the size dimension, a total of eight problems were arranged from the four size stimuli employed (see Table I for conditions by trials presentation). On four of the problems the relational response made after the transfer of size cues was correct, while in the other half of the problems a nonrelational response was correct. Thus on half of the problems after the shift in cues (e.g. from easy-to-hard), the correct response was based on the relational aspects of the stimuli used, for example, from large to medium large constituting the positive stimuli. In the other four problems the correct response after the transfer of cues necessitated a reversal response, for example, from large to medium small stimulus. Therefore, on any experimental session S received a total of 4 size problems, two of which were of an easy-to-hard condition and two of a hard-to-easy condition. Two of these problems maintained a transpositional response as correct after the transfer of cues while a nontranspositional response was correct after the shift for the other two problems.

Size problems were also presented with the restriction that no problem be followed by another problem which employed as a positive cue for training (i.e. trials 1 and 2) the same stimulus which served as the rewarded cue in the transfer trials (3 and 4) of the preceding size problem. This restriction insured that no stimulus was used as the rewarded cue for four consecutive trials.

Color problems were introduced by presenting for 2 trials, color stimuli of high saturation and on trials 3 and 4 shifting to identically colored stimuli but of a low saturation, or vice versa. From the eight color stimuli employed, a total of 8 color pair combinations were selected from the total number of combinations possible. Four of the problems were from high-to-low saturation and four of low-to-high saturation. During each experimental session four color problems were presented to S, two of these were of high-to-low and two from low-to-high saturation.

TABLE I

CONDITIONS BY TRIALS PRESENTATION

Size Problems

Trials	I		II		III		IV		V		VI		VII		VIII	
	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-
1 & 2	L	S	L	S	S	L	S	L	M_L	M_S	M_L	M_S	M_S	M_L	M_S	M_L
3 & 4	M_L	M_S	M_S	M_L	M_S	M_L	M_L	M_S	L	S	S	L	S	L	L	S

Stimuli are: large (L), medium large (M_L), medium small (M_S), and small (S). Problems 1 - 4 are easy-to-hard and problems 5 - 8 are of a hard-to-easy discriminability. Odd numbered problems maintain a relational positive stimulus following the shift (trial 3) and even numbered problems have a nonrelational positive stimulus after the shift.

Color Problems

Trials	I		II		III		IV		V		VI		VII		VIII	
1 & 2	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-
	R	B	G	R	Y	G	B	Y	G	B	R	G	Y	R	G	Y
	High		Low		High		Low		High		Low		High		Low	
3 & 4	R	B	G	R	Y	G	B	Y	G	B	R	G	Y	R	G	Y
	Low		High		Low		High		Low		High		Low		High	

Stimuli are: red (R), blue (B), green (G), and yellow (Y). The subscript - High or Low - indicates the level of saturation.

Color problems were arranged in such a fashion that for each color problem the positive stimulus from the preceding color problem was again present and paired with a new stimulus, but it now had a negative value. That is, the value of the old positive stimulus was reversed on the new color problem and it became the negative stimulus (see Table I for conditions by trials presentation).

A total of 8 size and 8 color problems were employed so that after every two experimental sessions S had responded to each problem once. In other words, one replication of all problems was completed after every two experimental sessions. The order of problem presentation during any experimental session was a size, color, size sequence (Table II illustrates one complete problem replication). The left-right first trial position was randomized in such a fashion that neither position appeared for more than three consecutive problems.

A noncorrection procedure was used with candy reward for correct responses. Intertrial intervals averaged 10 seconds and interproblem intervals averaged approximately 30 seconds. The experiment lasted for 24 days with a total of 96 size problems and 96 color problems per subject.

TABLE II

COMPLETE PROBLEM REPLICATION

Experimental Session One

Trials		I +	I −	II +	II −	III +	III −	IV +	IV −	V +	V −	VI +	VI −	VII +	VII −	VIII +	VIII −
Trials	1 & 2	L	S	R High	B	M_S	M_L	G Low	R	S	L	Y High	G	M_L	M_S	B Low	Y
	3 & 4	M_L	M_S	R Low	B	L	S	G High	R	M_S	M_L	Y Low	G	S	L	B High	Y

Experimental Session Two

Trials		IX +	IX −	X +	X −	XI +	XI −	XII +	XII −	XIII +	XIII −	XIV +	XIV −	XV +	XV −	XVI +	XVI −
Trials	1 & 2	G High	B	M_S	M_L	R Low	G	L	S	Y High	R	M_L	M_S	G Low	Y	S	L
	3 & 4	G Low	B	S	L	R High	G	M_S	M_L	Y Low	R	L	S	G High	Y	M_L	M_S

One complete replication of all problems as the sequence may have appeared for any two experimental sessions.

CHAPTER III

RESULTS

If the miniature experiment technique employed is to be satisfactory, significant amounts of learning must occur within the limited number of trials allotted each problem. To determine if large amounts of learning did occur, the percentage of correct responses for the first two trials were obtained for both size and color problems. That a substantial increase in learning does occur with just two trials of a problem is readily demonstrated by Table III.

TABLE III

PERCENTAGES OF CORRECT CHOICES ON TWO TRIALS FOR BOTH SIZE AND COLOR PROBLEMS

Problem	Size: Easy	Size: Hard	Color: High Saturation	Color: Low Saturation
Trial 1 % Correct	37	46	51	44
Trial 2 % Correct	90	78	87	84

Following this, a three-factor analysis of variance was computed by combining the number of correct responses for size and color problems (dimensions), by two levels of difficulty (easy or hard and high or low saturation), by trials (1 and 2). In order to gain a more sensitive analysis, through the increase in degrees of freedom, it was assumed that interactions with subjects were homogeneous, and consequently were pooled into a common residual term. This was done since it was thought that, since Ss were selectively chosen to participate in the experiment, differences between them were nil. In addition, the experimental design was such that if between S variance did exist, it would have been eliminated by the pretraining and warm-up trials given before each daily experimental session. Support for this assumption can be obtained from House and Zeaman (1963) and Zeaman, Thaller and House (1964), who in studies employing a similar design obtained no significant S interaction effects.

Table IV depicts the summary of the analysis of variance for the dimensions by difficulty by trials factorial. In this analysis all three main effects were significant: dimensions ($F = 7.21$, df 1/98, $p < 0.01$), difficulty ($F = 6.44$, df 1/98, $p < 0.05$) and trials ($F = 815.29$, df 1/98, $p < 0.001$). The two-way interaction of difficulty by trials was significant ($F = 9.18$, df 1/98, $p < 0.005$), as was the three-way interaction ($F = 20.33$, df 1/98, $p < 0.001$).

The significant main effect for dimensions possibly reflects a higher rate of performance on the color problems. Significance on the difficulty variable is attributed mostly to the size dimension (refer to Table III), and the high level of significance for trials was not an unexpected outcome. The statistically reliable trials main effect verifies that large amounts of learning do occur with just two trials of a problem.

TABLE IV

SUMMARY OF ANALYSIS OF VARIANCE FOR DIMENSIONS x DIFFICULTY x TRIALS

Source	df	SS	MS	F	
Within _S_s	14	13,192.25			
Dimensions (A)	1	99.01	99.01	7.21	$p < 0.01$
Difficulty (B)	1	88.41	88.41	6.44	$p < 0.05$
Trials (C)	1	11,194.00	11,194.00	815.29	$p < 0.001$
AB	1	27.07	27.07	1.97	
AC	1	33.08	33.08	2.41	
BC	1	126.08	126.08	9.18	$p < 0.005$
ABC	1	279.07	279.07	20.33	$p < 0.001$
Residual	98	1,345.53	13.73		

Separate analyses were made for just the size problem conditions. In these analyses, percent correct responses were tabulated for each problem condition over all trials (Table V) and a variance analysis was computed by using as the dependent measure number of correct responses. The analysis of variance was a 2 x 2 x 4 x 2 factorial, or difficulty by transposition-nontransposition by trials by first and second half replications. The results of this analysis are presented in Table VI.

TABLE V

PERCENTAGES OF CORRECT CHOICES ON FOUR TRIALS FOR ALL SIZE PROBLEM CONDITIONS

Problem: Size	Easy-Hard Transposition Correct	Easy-Hard Nontransposition Correct	Hard-Easy Transposition Correct	Hard-Easy Nontransposition Correct
Trial 1 % Correct	38	36	47	45
Trial 2 % Correct	92	88	82	74
Trial 3 % Correct	64	41	57	46
Trial 4 % Correct	75	80	91	91

From Table V it can be seen that noticeable amounts of learning occur between trials 1 and 2 for both easy and hard size problems. A significant trials main effect ($F = 254.34$, df 3/434, $p < 0.001$) reflects the learning which occurred between trials. It is important to note that on trial 2 the percent correct responses are higher for the easy (92 and 88%) than for the hard (82 and 74%) problems. The difference, however, was not large enough to produce a significant difficulty main effect in the variance analysis. On trial 3, the trial in which a shift in cues occur, performance rates are seen to drop to a chance level, although performance on the transposition correct problems (64 and 57%) is higher

TABLE VI

SUMMARY OF ANALYSIS OF VARIANCE FOR SIZE PROBLEMS DIFFICULTY (HARD-TO-EASY AND EASY-TO-HARD TRANSFER) x TRANSPOSITION - NONTRANS-POSITION x TRIALS x REPLICATIONS (1st and 2nd Half)

Source	df	SS	MS	F	
Within Ss	14	4,376.94			
Difficulty (A)	1	9.35	9.35	2.85	
Transposition-Nontransposition (B)	1	54.00	54.00	16.46	$p < .001$
Trials (C)	3	2,502.71	834.24	254.34	$p < .001$
Replications (D)	1	23.85	23.85	7.27	$p < .01$
AB	1	.61	.61		
AC	3	168.69	56.23	17.14	$p < .001$
BC	3	87.54	29.18	8.90	$p < .001$
AD	1	.11	.11		
BD	1	18.02	18.02	5.49	$p < .025$
CD	3	6.02	2.01		
ABC	3	19.13	6.38	1.95	
ABD	1	32.54	32.54	9.92	$p < .005$
ACD	3	2.30	.77		
BCD	3	14.62	4.87	1.48	
ABCD	3	15.77	5.26	1.60	
Residual	434	1,421.68	3.28		

than on nontransposition problems (41 and 46%). In the analysis of variance, the F-ratio for the transposition-nontransposition effect ($F = 16.46$, df 1/434, $p < 0.001$) confirms that this difference was highly significant. The decrement in responding when the non-transposed response was correct is an expected outcome, but the drop to chance-like responding on the problems for which a transposed response was correct, is contrary to what would be expected. Trial four performance is seen to be higher for problems which transfer from hard-to-easy discriminable cues (91 and 91%) than for problems which transfer from an easy-to-hard (75 and 80%) discrimination. These percentage differences are possibly reflected in a significant difficulty by trials interaction ($F = 17.14$, df 3/434, $p < 0.001$).

Percent correct responses were next tabulated for both color problem conditions over all trials. These percentages are contained in Table VII. A 2 x 2 x 4 factorial analysis was also performed on the data from this part of the experiment. The three variables analyzed in the statistical treatment were: saturation transfer condition, i.e., high-to-low and low-to-high saturation change of the irrelevant dimension; replications; and trials. A summary of this analysis can be found in Table VIII.

Examination of Table VII indicates that similar percent correct rates resulted over the four trials for both color shift conditions. This finding is supported by the fact that in the variance analysis the saturation transfer main effect ($F = 3.16$, df 1/210 $p > 0.05$) was not significant. The F-ratio for the trials variable ($F = 216.56$, df 3/210, $p < 0.001$) was highly significant as expected, and interestingly a saturation transfer by trials interaction ($F = 3.34$, df 3/210, $p < 0.05$) attained significance. This interaction is important because it reflects the large performance decrement which resulted on trial 3 by a shift in the level of the irrelevant dimension.

TABLE VII

PERCENTAGES OF CORRECT CHOICES ON FOUR TRIALS FOR COLOR PROBLEM CONDITIONS

Problem: Color	High - Low Saturation	Low - High Saturation
Trial 1 % Correct	51	44
Trial 2 % Correct	87	84
Trial 3 % Correct	61	59
Trial 4 % Correct	83	87

In order to determine if learning rates remained constant throughout all problem replications as assumed by House and Zeaman (1963), percent correct responses were obtained for trials 1 and 2 of all problems for the first and second half of the experiment. This amounted to tabulating percentages of correct responses for the first and second six replications of each problem. From Table IX it can be seen that higher rates of correct responding are evident on trial 2 of all problems in the second half of the replications.

TABLE VIII

SUMMARY OF ANALYSIS OF VARIANCE FOR COLOR PROBLEMS SATURATION TRANSFER CONDITION (HIGH-TO-LOW AND LOW-TO-HIGH) x REPLICATIONS (1st vs. 2nd HALF) x TRIALS

Source	df	SS	MS	F	
Within Ss	14	5,278.50			
Saturation Transfer (A)	1	18.15	18.15	3.16	
Replications (B)	1	209.06	209.06	36.36	$p < 0.001$
Trials (C)	3	3,735.73	1,245.24	216.56	$p < 0.001$
AB	1	.15	.15		
AC	3	57.65	19.22	3.34	$p < 0.05$
BC	3	35.54	11.85	2.06	
ABC	3	14.45	4.82		
Residual	210	1,207.77	5.75		

TABLE IX

PERCENT CORRECT RESPONSES FOR TWO TRIALS
FOR BOTH SIZE AND COLOR PROBLEMS
FOR THE FIRST AND SECOND HALF
OF THE EXPERIMENT

FIRST PART REPLICATIONS

Problem	Size: Easy	Size: Hard	Color: High Saturation	Color: Low Saturation
Trial 1 % Correct	35	45	50	39
Trial 2 % Correct	88	74	84	81

SECOND PART REPLICATIONS

Problem	Size: Easy	Size: Hard	Color: High Saturation	Color: Low Saturation
Trial 1 % Correct	39	43	52	48
Trial 2 % Correct	92	82	90	86

To more fully examine differences in responding over replications, percentages were tabulated separately for size and color conditions for both halves of the experiment. These percentages are shown in Tables X and XI. Careful examination of each table reveals that responding was not invariant across replications.

If a comparison is made of the two parts of Table X, it can be readily seen that for the majority of trials, higher correct response rates were obtained in the second half of problem replications. In the variance analysis (refer to Table VI), a significant replications effect ($F = 7.27$, df 1/434, $p < 0.01$) confirmed that responding was not constant throughout the experiment. A significant two-way interaction of transposition-nontransposition by replications ($F = 5.49$, df 1/434, $p < 0.025$), as well as a difficulty x transposition-nontransposition x replications ($F = 9.92$, df 1/434, $p < 0.005$) interaction implies that Ss were responding differently in the second half of the experiment.

In considering trial differences over replications for the color problems, it can be seen from Table XI that in every case trial performance was higher in the second half of the experiment. The difference over replications was found to be highly significant ($F = 36.36$, df 1/210, $p < 0.001$) in the analysis of variance (see Table VIII).

Certain individual trial comparisons were also of importance. These comparisons were of interest since it was necessary to determine if performance from trial to trial varied as a function of the type of transfer condition (e.g. easy-to-hard) investigated. The

TABLE X

PERCENT CORRECT RESPONSES FOR FOUR TRIALS
FOR ALL SIZE PROBLEM CONDITIONS
FOR THE FIRST AND SECOND HALF
OF THE EXPERIMENT

FIRST PART REPLICATIONS

Problem: Size	Easy-Hard Transposition Correct	Easy-Hard Nontransposition Correct	Hard-Easy Transposition Correct	Hard-Easy Nontransposition Correct
Trial 1 % Correct	43	28	48	43
Trial 2 % Correct	93	83	75	73
Trial 3 % Correct	69	34	54	48
Trial 4 % Correct	72	77	89	89

SECOND PART REPLICATIONS

Problem: Size	Easy-Hard Transposition Correct	Easy-Hard Nontransposition Correct	Hard-Easy Transposition Correct	Hard-Easy Nontransposition Correct
Trial 1 % Correct	33	45	38	47
Trial 2 % Correct	91	93	88	75
Trial 3 % Correct	59	48	59	45
Trial 4 % Correct	79	83	92	94

TABLE XI

PERCENT CORRECT RESPONSES FOR FOUR TRIALS FOR COLOR PROBLEMS FOR THE FIRST AND SECOND HALF OF THE EXPERIMENT

FIRST PART REPLICATIONS

Problem: Color	High - Low Saturation	Low - High Saturation
Trial 1 % Correct	50	39
Trial 2 % Correct	84	73
Trial 3 % Correct	53	54
Trial 4 % Correct	80	84

SECOND PART REPLICATIONS

Problem: Color	High - Low Saturation	Low - High Saturation
Trial 1 % Correct	52	48
Trial 2 % Correct	90	86
Trial 3 % Correct	69	65
Trial 4 % Correct	87	91

Newman-Keuls test (Winer, 1962) was employed for making these comparisons. Table XII presents the trial comparisons for the size problem conditions which were of importance. It is interesting to note that trial 1 and 3 and trial 2 and 4 comparisons on the difficulty variable (i.e., easy-to-hard cue shift, or vice versa), did not differ significantly, whereas the other comparisons did.

TABLE XII

INDIVIDUAL COMPARISONS FOR SIZE PROBLEMS

Individual trial performance compared using the Newman-Keuls procedure. Trials (c) are ordered from low to high mean performance and comparisons attaining significance are indicated by asterisks (* $p < .05$; ** $p < .01$).

Easy-to-Hard

	c_1	c_3	c_4	c_2
c_1		N.S.	**	**
c_3			*	**
c_4				N.S.

Hard-to-Easy

	c_1	c_3	c_2	c_4
c_1		N.S.	**	**
c_3			*	**
c_2				N.S.

Transpose Response Correct

	c_1	c_3	c_4	c_2
c_1		N.S.	**	**
c_3			N.S.	*
c_4				N.S.

Nontranspose Response Correct

	c_1	c_3	c_2	c_4
c_1		N.S.	**	**
c_3			**	**
c_2				N.S.

Comparison of trials 1 and 3 on the transposition-nontransposition variable is also noteworthy. In both comparisons the trials are not significantly different, implying that performance dropped to chance on both of these trials, regardless of the fact that S could have maximized reward by always making a transposition response on trial 3 of all size problems.

Trial 2 performance on the easy size problems was next compared with trial 2 of the hard (i.e. small cue difference) discrimination problems. Also, trial 4 performance was compared for problems transferring from easy-to-hard discriminability, or vice versa. These comparisons were made by employing a t-test for correlated observations. The trial 2 comparison ($t = 4.35$, df 14) was significant at the 0.001 level as was the trial 4 comparison ($t = -4.62$, df 14).

In order to test the affect of transfer of training, trial 2 easy discrimination performance was compared with trial 4 easy after the two training trials (i.e., 1 and 2) had been on a hard problem condition. Trial 2 hard was also compared with trial 4 hard to determine if there was an effect for transferring from easy-to-hard discriminable stimuli. The two comparisons were not significant ($t < 1$).

Individual comparisons were also made for trial performance on the color problems. Again, the Newman-Keuls procedure was employed in making these comparisons and trial performance was obtained by collapsing for correct responses across trials of both levels of color saturation change. Reference is made to Table XIII. All comparisons significantly varied from each other ($p < 0.01$), with the single exception of the trial 2 and 4 ratio.

Two other comparisons were made employing t-tests for correlated observations. In the first comparison, the difference between trial

2 performance for the high and low saturation conditions was not significant ($t = 1.29$, $p > 0.05$), nor was the comparison of trial 4 performance for problems transferring from high-to-low and low-to-high saturation ($t = -1.43$, $p > 0.05$).

TABLE XIII

INDIVIDUAL COMPARISONS
FOR COLOR PROBLEMS

Individual trial performance compared using the Newman-Keuls procedure. Trial performance was obtained by collapsing for correct responses across trials of both levels of color saturation change. Trials (c) are ordered from low to high mean performance and comparisons attaining significance are indicated by asterisks (** $p < .01$).

	c_1	c_3	c_4	c_2
c_1		**	**	**
c_3			**	**
c_4				N.S.

CHAPTER IV

DISCUSSION

The purpose of the present study was twofold: (1) to investigate transfer discrimination between cues of different discriminable distance once the probability of attending to the relevant dimension (Po) was high, and (2) to determine whether a change in the level of a constant irrelevant dimension would affect the level of performance in a two choice discrimination task.

In order to discuss the results of this study in relation to the two stated objectives, the results from the analyses pertaining to the first purpose will be viewed in the first section of this chapter, while the latter part of the chapter will be reserved for discussion of the second objective.

Cue Difference and Transfer Discrimination

Data analyses indicated that, even though performance was lower for percent correct responding between stimuli of small physical cue difference, no statistically reliable effect was obtained for the difficulty main effect. Only a trend ($p < 0.10$) was found to indicate that performance was slightly affected by difficulty. The analyses did, however, show a significant difficulty by trials interaction. This interaction can best be understood by referring to Table V. If all trial 2 percentages are compared with all trial 4 percent correct responses, it is evident that in the easy-to-hard transfer condition the rates decrease from 92 and 88% (trial 2) to 75 and 80% (trial 4), while correct responding on the hard-to-easy transfer increases from 82 and 74% to 91 and 91%. This table of percent correct responses reflects the interaction of transfer in problem difficulty by trials. This difficulty by trials interaction probably served to obscure the difficulty main effect. It should be noted though, that when individual comparisons were made using the Newman-Keuls procedure, in no instance was a trial 2 and trial 4 comparison significant.

The most important finding from the analyses, however, appeared when t-tests computed between trial 2 easy and trial 2 hard discriminations, and a similar trial 4 comparison, attained a high level of significance ($p < 0.001$). From this, it can be concluded that cue differences do have an affect upon discrimination, even though Po is high. However, it cannot be concluded that transfer of training (i.e., easy-to-hard and hard-to-easy) improved learning efficiency once Po was high since t-tests employed to make transfer of training comparisons (trial 2 hard vs. trial 4 hard and trial 2 easy vs. trial 4 easy) were not significant.

The implicit assumption made in Attention Theory that if the probability of attending to the relevant dimension, in this instance - size, is high, performance from an easy-to-hard size problem or vice versa, should not result in a differential rate of performance, is not supported. The results of this study indicate that cue difference continues to exercise control in the discriminative situation, even after the S has undergone extensive pretraining and is functioning with a high Po.

If it is the case that Po is high at the conclusion of pretraining and cue differences continue to affect discriminative responding, an explanation must be sought by employing some other parameter of the theory. To account for the results, speculation can be made through the consideration of two parameters in the theory, other than Po. The first of these is the θ parameter which is the learning rate constant. It may be that different θ's exist for the easy and the hard size problems. Speculation about differential θ's is not profitable, however, since Zeaman and House (1963) have found that learning rate, θ, is not a particularly important source of variance in discrimination learning of retardates. Possible a more advantageous position would be to theorize a generalization of Pr, the instrumental probability of approaching the positive cue, when cue differences are small and Po at unity.

As will be discussed shortly, the significant replications main effect suggests that Po was not at unity at the conclusion of pretraining and that growth of Po continued to improve over problem replications. This is important since it further suggests that even though pretraining was extensive, it was not sufficient to take Po to unity, and with growth of Po over replications the cue difference variable may have continued to operate through Po to control discriminative responding.

In order to determine if cue difference continued to affect discriminations when Po differed for the two halves of the experiment, certain individual trial comparisons were made for the first half and the second half of problem replications. It was reasoned that if the comparisons were significant for the first half of the replications, but not for the second half, it could be assumed that cue difference operates through Po since this parameter was evidently higher, and possibly at unity, in the second half of the replications. But if the comparisons were significant for both halves of the experiment, it could be concluded that a parameter other than Po was being influenced by cue differences.

To make these comparisons, t-tests were computed for trial 2 easy and trial 2 hard and trial 4 easy-hard and trial 4 hard-easy discriminations for both halves of problem replications. As was the case when t-tests were computed employing all replications, these t-values also attained significance. The trial 2 easy and trial 2 hard comparisons were $t=3.26$ (df 14, $p < 0.01$) for the first half of the replications and $t=2.99$ (df 14, $p < 0.01$) for the second half replications. Trial 4 comparisons were $t= -5.02$ ($p < 0.001$) for first half replications and $t= -3.59$ ($p < 0.01$) for second half replications.

These comparisons demonstrate that although Po was still higher in the latter half of the experiment, cue differences continue to control the subject's ability to discriminate. This lends support to the notion that a parameter other than Po must be employed to account for the results obtained. It was suggested earlier that generalization of the Pr parameter, as a consequence of small cue difference, could possibly be offered as a means of accounting for the results.

This finding, that cue differences have an affect upon discrimination, is important to Attention Theory since the question of generalization has been largely ignored by the advocates of the theory. One theory of discrimination learning (Restle, 1955), would have predicted part of the results found in the present study. Restle assumes that if two problems are run under the same conditions but differ only in degree of difference between stimuli, the same cues are involved, but the greater the differences to be discriminated, the greater the number of relevant cues and the less the number of irrelevant cues. From this assumption, Restle was able to develop a mathematical equation which could be used to predict the results of Lawrence's (1952) study of easy-to-hard discrimination with rats. Likewise, Restle would have predicted the significant easy-hard cue difference effect obtained herein.

By an extension of the reasoning behind his equation, Restle (1955) was able to predict performance from hard-to-easy problems with human Ss. He assumed that there are cues which are relevant in an easy problem, but irrelevant in a hard problem. These cues, Restle argues, cannot be identified in the hard problem and if performance is to be perfect in the easy problem, all the relevant cues must be identified. Thus, when a S transfers from a hard to an easier problem he would expect some small number of errors to be made. Contrary to Restle's contention, however, such was not the case in the present study. When Ss first responded on a hard problem and then on an easier problem, performance decrements were not apparent as Restle's theory predicts, rather increments in discriminative responding were apparent (see Tables V and X).

Thus Restle's theory can be only employed, in part, to account for the results of the present study. It seems reasonable to assume that Attention Theory could parsimoniously handle the data if a generalization postulate could be adopted to account for discriminative responding between cues of different discriminable distances once the Po of attending to the relevant dimension was high. At present, Attention Theory has no generalization postulate, and it is suggested that closer examination be given to Pr as a possible means of accounting for the results obtained in this study.

To continue, the analyses also resulted in a significant main effect for the transposition-nontransposition, trials and replication variables. These will be discussed in order of presentation.

The transposition-nontransposition variable was included in the experimental design to serve as a control for relational effects. It can be concluded that this control measure effectively served its purpose. It may seem, from a study of Tables V and X, that this control factor exercised little usefulness in the transfer discrimination task, since performance on trial 3 of all problems dropped to a chance level of correct responding. Nonetheless, it is apparent that performance was still lower on trial 3 for all problems which served as a control for transposition.

The trials main effect was expected to be highly significant, since large amounts of learning must occur in the few trials of each problem. Otherwise, the 4-trial design employed would not have been justified.

When problem replications were divided into a first and second part variable and tested in the analysis of variance, a significant F-ratio was surprising, even though Table X indicated that performance differed in the two parts of the experiment.

This significant effect is interesting because it suggests that a learning set was developed by the Ss during the course of this experiment. If this learning set phenomenon is real, it is contrary to what House and Zeaman (1963) would expect to occur in their miniature experiment technique. In adopting their method of experimentation, they were forced to rule out learning set because stable learning rates were a requirement of their design. To support their assumption that stable rates of learning could be secured from their design without learning set formation, they offered the results of an earlier research (House and Zeaman, 1958) in which it was found that learning set was not evident with retardate Ss who had been trained to a criterion on pretraining problems.

So, two reasons can be offered to account for the significant replications effect found in this study. First, too limited a number of problems may have been employed, thereby accounting for learning set formation over problem replications. This explanation is not satisfactory, however, in light of a further assumption made by Zeaman and House which states, in effect, that a large collection of homogeneous problems is not needed since ". . .the same stimuli can be re-used with the same subject without transfer providing that one or more different problems intervene." (House and Zeaman, 1963; p. 319). This implies that many problems can be arranged with just four stimuli. In the present study, four size stimuli were used to arrange a series of eight problems and during each experimental session an alternating size, color, size sequence was used which should have been sufficient to eliminate undesireable transfer effects.

Second, it is feasible that the House-Zeaman assumption is faulty and that learning set formation occurs, even when an S is pretrained to a high degree of sophistication. It would be interesting to see if a replications effect could be obtained in a reanalysis of the House-Zeaman data.

The importance of this finding is that it suggests that Po was not at unity when pretraining ceased and the experiment proper commenced. If this is the case, it would have produced the significant replications effect, since learning rate; i.e., growth of Po, was still continuing to show improvement over problem replications.

Several interaction effects were significant and warrant discussion. The first of these was the transposition-nontransposition by trials interaction. Interpretation of this interaction is easily made in light of the fact that on the third trial of every problem a change in cues occurred and for half of these trials, the transfer maintained the relational cue positive (e.g., large to medium-large cue positive). On the other transfer trials, a non-relational cue was made positive. Consequently, a shift in cues to control for transpositional effects interacting with trials is not to be considered unusual in the repeated measures design.

A transposition by replications interaction also must be interpreted. If one examines trial 3 performance for the first and second part replications (see Table XIV), it is apparent that the percentages change with replications.

TABLE XIV

PERCENTAGES OF CORRECT CHOICES ON TRIAL 3
FOR THE FIRST AND SECOND HALF
OF THE EXPERIMENT

	Easy-to-Hard transposition Correct	Easy-to-Hard nontransposition Correct	Hard-to-Easy transposition Correct	Hard-to-Easy nontransposition Correct
First Part Replications				
Trial 3	69	34	54	48
Second Part Replications				
Trial 3	59	48	59	45

It seems that responding on trial 3 in the second half of the experiment was beginning to stabilize, with performance maintaining a slightly higher than chance level (59%) on trials having the transposed size cue positive, while a slightly lower than chance rate of performance (48 and 45%) was evidenced for trials having a nontransposed cue of positive value. Moreover, this interaction can be interpreted to mean that the S's tendency to respond to the relational aspects of the size dimension were being extinguished in the second half of the experiment.

A three way interaction, difficulty x transposition-nontransposition x replications, is more difficult to interpret. It can, however, be stated that this interaction reflects the wide range of percentage differences over all problem conditions which resulted on trial 3 in the first half of the replications. It can be seen in Table XIV that there is a difference of 15% correct responding between the easy-hard and hard-easy transposition correct conditions and a 14% difference between the easy-hard and hard-easy nontransposition correct condition in the first half of the problem replications. This interaction is especially highlighted by the strong tendency which Ss demonstrated in making a relational response on trial 3 when the cue transfer went from easy-to-hard. In the second half of the replications, differences are negligible except for a small 3% difference between the easy-hard and hard-easy nontransposition conditions.

No other interactions were significant, and it is important to point out that there were a total of 11 possible interaction effects in the analysis, for which only 4 attained significance.

In summary, the results for this first part of the investigation indicate that:

1. Cue difference does affect discriminative responding, and this effect is strong enough to reflect a high degree of differential performance, even after an S has been trained to attend to the relevant dimension of a two choice discrimination problem. Moreover, this effect persisted, even though Po continued to show improvement over problem replications.

2. It was suggested that Attention Theory could account for the results obtained herein, if a generalization postulate could be adopted for discriminative responding between cues of different discriminable distances once Po was high. It was further suggested that closer scrutiny be given to the Pr parameter in this regard.

3. The control employed for transposition was effective.

4. A significant replications effect suggests that learning set formation occurs in the miniature experiment technique, even though the S has been pretrained. It was further suggested that pretraining may not have been sufficient to take Po to unity.

Change in the Level of the Irrelevant Dimension

The saturation transfer main effect in the analysis of variance for the color problem conditions was not significant. Only a trend ($p < 0.10$) in this direction was found. The saturation transfer by trials interaction was significant and can be interpreted as demonstrating that a gross change in the level of an irrelevant dimension does produce a change in performance across trials. Tables VII and XI depict this interaction. In addition, careful attention to these tables indicates that it was important whether the relevant dimension (color) was of high or low irrelevant saturation, since it is shown that performance was somewhat depressed when the relevant dimension was associated with a low saturation irrelevant dimension. But, trial comparisons to test this were not significant ($p > 0.05$).

The result of major interest in this analyses is the significant trials main effect. What is interesting is that trial 3 performance resulted in a performance decrement from the previous high percent correct rate which had been attained on trial 2. Tables VII and XI show this drop in performance. Individual trial comparisons between trials 2 and 3 and 3 and 4 were significant ($p < 0.01$).

It was expected that a constant high rate of correct responding would be demonstrated on trials 2, 3 and 4. This was so since the increase in learning on any problem occurs from trial 1 to 2. And, if the relevant dimension remains unchanged throughout all trials, the same high rate of correct responding would be anticipated. Therefore, the difference which appeared between trials 2 and 3 and 3 and 4 is important, because a change occurred only in the level of the irrelevant dimension with the positive cue of the relevant dimension remaining fixed throughout the problem.

Why is it that a change, in a dimension which is supposedly nonfunctional (Restle, 1955; 1962), is able to produce significant decrements in performance? It would seem reasonable to assume from the results of this study that the irrelevant dimension is functional in the discrimination learning situation. But what is the role of irrelevant dimension, if they are not "adapted out" as the results of this study indicate.

House and Zeaman (1963) and Zeaman, Thaller, and House (1964) have demonstrated that a difference exists in discriminative responding when variable and constant irrelevant dimensions are compared. They have shown that higher performance rates are attained when the irrelevant dimension is constant, rather than variable. This finding has led them to conclude that compound cues are formed when a problem involves a constant irrelevant dimension. These compound cues are capable of adding to the number of relevant dimensions which can be used as a basis for making a discrimination between two stimuli. It might well have been the case, in the present study, that compound cues were formed during trials 1 and 2, and the change in the level of the irrelevant dimension on trial 3 served to break up this compound and reduce the number of relevant dimensions available. This reduction in relevant dimensions may then have been responsible for the decrement in performance on trial 3.

Speculation about the nature of the compounds which were possibly formed is limited. It seems reasonable to assume that the compounds were formed through the combination of color cues of the relevant dimension with some complex stimulus property of the irrelevant dimension. These compounds may have been of a color-saturation, color-brightness, or of a complex color-brightness-saturation interaction.

If compound cues were formed and added to the number of relevant dimensions available, the decrement in performance which resulted when a shift occurred in the level of the irrelevant dimension would have been predicted by House and Zeaman (1963). These investigators have demonstrated diminished response rates when compound cues were broken up by changes in cues of the irrelevant dimension. Therefore, it seems tenable to assume that unspecifiable compound cues (color-X compounds) were formed during trials 1 and 2 and underwent some change on trial 3 which produced a drop in performance.

The variance analysis also resulted in a significant main effect for replications ($p < 0.001$). Discussion of this result will be limited, since what was said earlier in this chapter about a significant main effect for replications is applicable here. The difference over replications can be seen by referring to Table XI. Clearly, responding improved in the latter half of the problems. This suggests that the probability of attending to the relevant dimension (Po) was not as high (i.e., 1.0) as is assumed in the miniature experiment technique, once the S satisfactorily passes the stringent pretraining criterion. From this it can be concluded that learning set, or the growth of Po, also developed in the course of this part of the experiment.

To summarize:

1. It is evident that a gross change in the level of an irrelevant dimension does produce a differential rate in responding. This is contrary to what would be predicted by Restle's theory, but can be handled by recent findings of House and Zeaman (1963) and Zeaman, Thaller, and House (1963).

2. It appears that this change in performance can be attributed to the destruction on trial 3 of a color-X compound which is formed on trials 1 and 2.

3. A replications main effect also suggests that growth of Po occurred during the course of the experiment.

CHAPTER V

SUMMARY AND CONCLUSIONS

This investigation was designed to study cue changes in a relevant size dimension and in an irrelevant saturation dimension. More specifically, the purpose of this study was to determine if the following assumptions could be empirically supported:

1. The implicit assumption made in Attention Theory (Zeaman and House, 1963) that if the probability of attending to the relevant dimension is high, transferring from an easy to a hard problem or vice versa, should not result in a differential rate of performance.

2. The assumption (Restle, 1955) that constant irrelevant dimensions are nonfunctional and "adapted out" of the two choice discrimination situation.

To test the first assumption, a relevant size dimension was employed and cue changes occurred in the physical distance between the cues. To test the second assumption a gross change was manipulated within the level of an irrelevant saturation dimension.

Fifteen retardate subjects were selected to participate in the experiment. A miniature experiment technique was employed and all subjects received a total of 96 4-trial size problems and 96

4-trial color problems. This method was used since it assumes that at the conclusion of pretraining all subjects are responding with a Po at unity with tendencies to respond to irrelevant cues extinguished.

The results of the statistical analyses computed on the data for the two parts of the experiment indicate that the two assumptions tested were not empirically supported.

It was found that cue differences do affect discriminative responding, even after an S has been trained to attend to the relevant dimension. However, it was proposed that Attention Theory could account for the results, if a generalization postulate could be adopted for discriminative responding between cues of different discriminable distances once Po was high. It was further suggested that closer examination be given to the Pr parameter in this regard.

In addition, a significant replications effect indicated that learning set formation, i.e., growth of Po, occurred during the course of the investigation.

It was also apparent that a gross change in the level of an irrelevant dimension does produce a differential rate in responding. This implies that irrelevant cues are functional in the two choice discrimination situation. It was suggested that some unspecifiable aspect of the irrelevant dimension combined with the relevant color dimension to form a compound cue. This color-X compound cue added to the number of relevant dimensions which could be used by an S as a basis for making a discrimination. Further, the performance decrement which appeared after the shift in the level of the irrelevant dimension (trial 3) was attributed to the destruction of the compound which was formed on trials 1 and 2.

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