EFFECT OF A PARTIALLY CORRELATED DIMENSION ON DISCRIMINATION LEARNING IN CHILDREN

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CHAPTER I

THE PROBLEM

Introduction

Within the past decade psychologists have invested an ever increasing amount of empirical and theoretical effort into an exploration of the process of discrimination learning. A basic paradigm used by many investigators involves a two-choice discrimination problem in which approach tendencies are conditioned to one stimulus and avoidance tendencies to the other. This provides a highly controlled situation in which the effects of different variables can be determined and predictions from various theoretical models can be precisely tested.

In considering a two-choice discrimination problem it is convenient to make a distinction between dimensions and cues of the problem, following the practice of several investigators including Zeaman and House (1963), Sutherland (1964) and Goodwin and Lawrence (1955). For instance, Zeaman and House define dimensions as "broad classes of cues which have a common discriminative property." (p. 168) Examples of dimensions which have been commonly employed in discrimination learning problems are color, size, form, brightness, numerosity and position. Cues, then, are specific elements within a given dimension. To illustrate, a two-choice problem involving the dimension of color might employ the cues of green vs. yellow; that is, approach tendencies would be conditioned to green (or yellow) and avoidance tendencies to yellow (or green). Similarly, if the form dimension were used, the selected cues could be square vs. cross, or possibly circle vs. triangle. Obviously the number of possible dimensions and cues within a dimension that could be used in a given problem is considerable.

If a problem can be solved by approaching a square and avoiding a circle the form dimension is said to be relevant. All dimensions which cannot be used as a basis for solving the problem are termed irrelevant. Most research in discrimination learning has been done with the relevant dimensions being perfectly correlated with reward and the irrelevant dimensions having a zero correlation with reward. For example, if the relevant dimension is color with red the positive cue and green the negative cue, then red would always be associated with reward and green never associated with reward. If on the same problem form is an irrelevant dimension, then each form cue would be associated with reward on 50 per cent of the trials.

However, it is also possible to arrange experimental conditions such that a given dimension is partially correlated with reward and the relevant dimension of the problem. Zeaman and House (1963) have presented a convenient method of representing this type of situation. In their system the parameter ρ represents the degree of relevance of a given dimension or the correlation of that dimension with the reference dimension. The reference dimension is a dimension which is perfectly correlated with reward. Therefore, the probability that the cues of the jth dimension are associated with (i.e. in the same place as) those of the reference dimension (S_1) is equal to ρj. For example, if the reference dimension (S_1) were color, with yellow as the positive cue (s_1) and blue as the negative cue (s_1'), then yellow would always be associated with reward and blue never associated with reward. It can then be experimentally arranged such that form is a partially correlated (nonreference) dimension (S_2), with the two cues being a square (s_2) and a circle (s_2'). If ρ_2 = .75 then s_2 would be associated with s_1 on 75 per cent of the trials and with s_1' on 25 per cent of the trials. Likewise, the probability that s_2' would be associated with s_1' would be .75 and the probability that s_2' would be associated with s_1 would be .25. This means that on 75 per cent of the trials the reinforced stimulus would be a yellow square, and on 25 per cent of the trials the reinforced stimulus would be a yellow circle. These relationships are depicted in Figure 1.

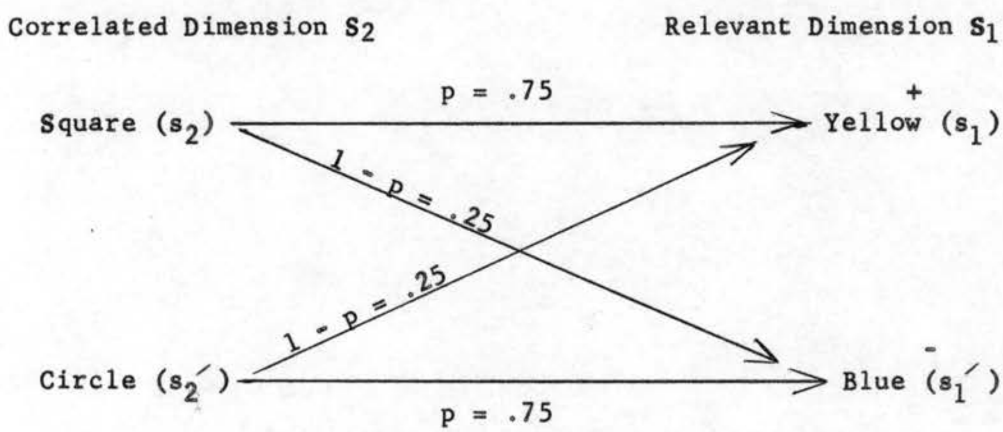

Figure 1. Illustration of the Relationship Between the Reference (S_1) Dimension and the Partially Correlated Dimension (S_2)

Theoretical Background

Originally the use of partially correlated dimensions grew out of attempts to resolve the continuity-noncontinuity issue in discrimination learning, or, as it was often called, the Spence-Lashley controversy. As the chief advocate of noncontinuity theory Lashley (1942) described discrimination learning as a hypothesis-forming and hypothesis-testing process in which the organism entertains only one hypothesis at a time. Accordingly, in the pre-solution period the organism learns only about the incorrectness of the particular hypothesis it is working with and nothing about the correct hypothesis. Only as the organism abandons an incorrect hypothesis for the correct hypothesis does it learn anything about how to solve the problem. In other words, the organism at any given instant is responding only to a selected portion of the entire stimulus complex.

In contrast, continuity theory (Spence, 1936) states that all aspects of the stimulus complex impinging upon the senses develop excitatory or inhibitory potential, depending upon whether or not the organism is reinforced. The organism does not respond to a selected portion of the stimulus situation.

Mackintosh (1965) has couched the continuity and noncontinuity positions in the more contemporary terms of attention processes. He concludes that straight noncontinuity postulates that an organism attends only to one dimension at a time over a series of trials. Thus, nothing is learned about those dimensions which are not being attended to at a given moment. Continuity theory, on the other hand, postulates that an organism attends to all dimensions impinging upon the senses and that it learns equally about all cues within these dimensions.

Statement of the Problem

In general, the present problem is concerned with (a) the effects of a partially correlated dimension upon the learning of a two-choice discrimination problem by normal grade school children, and (b) the subsequent learning of a transfer problem in which the partially correlated dimension of the original problem becomes the new relevant dimension of the transfer problem. Each subject (S) was first presented with a training problem in which form (or color) was the relevant dimension and color (or form) was a 90-10, 75-25 or 50-50 correlated dimension. Upon learning the training problem S was given a transfer problem in which the previously correlated dimension became the relevant dimension. Depending upon S's group assignment, the positive cue of the transfer problem was either the cue which had been more frequently reinforced in the training stage, or it was the cue which had been less frequently associated with reinforcement in the training stage.

Theoretical Implications of the Problem

If children solve a discrimination problem in a noncontinuity fashion, they should, over a series of trials, respond only to the relevant dimension of the training problem and should learn nothing about the significance of the partial correlation of the nonreference dimension. Therefore, the degree of relevance of a partially correlated dimension during training should have no differential effect upon performance in the training problem or the transfer problem.

If, however, discrimination learning in children is a process accurately described by continuity theory, Ss should not only build up excitatory and inhibitory potential to cues of the reference dimension but also to cues of the partially correlated dimension. Due to the summation of habit strength conditioned to the various cues of the reference and nonreference dimensions it follows that the tendency to approach the positive stimulus should be greater when s_2 is associated with s_1 than when s_2 is associated with s_1' (see Figure 1). Since

s_2 is associated with s_1 most often in the 90-10 condition, continuity theory would predict that there should be fewer errors on a training problem with 90-10 nonreference dimension than on a training problem with a 75-25 or a 50-50 nonreference dimension. Likewise there should be fewer errors in the 75-25 condition than in the 50-50 condition. In the transfer condition continuity theory would predict that performance should be better when the positive cue is the cue that was more frequently reinforced in the training condition than when the positive cue is the cue that was less frequently reinforced in the training condition.

CHAPTER II

REVIEW OF THE LITERATURE

Bitterman and Coate (1950) have reported two experiments in which rats were trained on a two-choice discrimination problem with one relevant dimension and a nonreference dimension which was correlated 80-20 with the reference dimension. After learning this original problem <u>S</u>s were transferred to a second problem in which the previous nonreference dimension was then perfectly correlated with reward.

In Experiment I <u>S</u>s were trained on a Lashley jumping apparatus with brightness as the reference dimension and position as the non-reference dimension. Upon reaching criterion on the training problem <u>S</u>s were assigned to one of two transfer conditions. For Group 80 the positive cue of the new reference dimension was the cue that had been associated on 80 per cent of the trials with the positive cue of the reference dimension of the training problem. Conversely, the positive cue of the transfer problem for Group 20 had been associated with the positive cue of the reference dimension in the training problem on 20 per cent of the trials. The original brightness cues appeared equally often in each position in accordance with the Gellermann series (1933). The results indicated that the <u>S</u>s in Group 80 performed significantly better on the transfer problem than did the <u>S</u>s in Group 20.

Experiment II reported by Bitterman and Coate (1950) was similar to Experiment I except that an attempt was made to establish a "perceptual set" for position cues before introducing brightness as a partially correlated dimension. In Stage I rats were trained on an elevated Y maze where either the right or left arm of the maze was correct. Brightness cues were randomly associated with reward. In Stage II position remained the reference dimension but brightness became an 80-20 partially correlated dimension. Finally, as in Experiment I, a transfer problem was introduced where the previously partially correlated dimension became the relevant dimension. The position of the correct alley was determined by the Gellermann series. Again it was found that Group 80 performed better than Group 20 on the transfer problem.

Jeeves and North (1956) also performed a study involving a partially correlated dimension. Task 1 for all rats consisted of a relevant form dimension problem with a 75-25 partially correlated brightness dimension. After 128 trials on the form discrimination all Ss were given Task 2 in which the form cues disappeared and the brightness cues were the same as those used in Task 1 and were perfectly correlated with reward. For Group 75 the positive brightness cue was the cue that had been associated 75 per cent of the time with the positive form cue in Task 1, and for Group 25 the positive brightness cue was the cue that had been associated with the positive form cue 25 per cent of the time. The data revealed that on Task 2 Group 75 learned more rapidly than Group 25, and both groups showed an initial tendency on Task 2 to approach the 75 per cent brightness cue. Similarly, on Task 1 more errors occurred when the 75 per cent brightness cue was paired with the negative form cue than when it was paired with the positive form cue.

In a follow-up study Hughes and North (1959) essentially replicated the Jeeves and North (1956) study with the exception that brightness did not become a 75-25 partially correlated dimension until Ss had learned the original form relevant-brightness irrelevant problem plus 108 overtraining trials. Again, Group 75 learned the transfer problem significantly faster than Group 25.

The results of these studies have been interpreted as lending support to continuity theory but causing difficulties for noncontinuity theory. Basically the argument against noncontinuity theory states that if Ss selectively attend to one dimension of the stimulus complex they learn nothing about other dimensions of the problem. Therefore, if Ss learn to solve a problem on the basis of the form dimension they should learn nothing about a partially correlated color dimension, and, as a consequence, performance on transfer problems should be no better for Group 75 than for Group 25.

Continuity theory, on the other hand, can adequately handle these effects by postulating that more habit strength is built up to the brightness cue that is more frequently reinforced in training. Therefore, on the transfer problem there should be a greater tendency to respond to the cue that had the higher correlation with reinforcement during the original problem. It follows then that Group 75 should learn faster than Group 25 in transfer.

CHAPTER III

METHOD

Ss were 79 normal children from the second, third and fourth grades of Jefferson Public Grade School, Stillwater, Oklahoma. Nineteen of the original 79 Ss failed to reach learning criterion for the training problem and were not used in the transfer condition. The 60 remaining Ss, which had been randomly assigned to the three training conditions, were also randomly assigned to one of the two transfer conditions after completing a given training problem. Table I presents descriptive statistics for the main experimental groups.

Apparatus

The apparatus was basically a model of the Wisconsin General Test Apparatus (WGTA; Harlow, 1942), but modified for easy portability and use with children. It consisted of a 36- by 36-inch, portable platform upon which could be placed an 18- by 30-inch sliding stimulus tray. Two circular reinforcement wells, two and one-half inches in diameter, were centered in the tray nine inches from each end. A 24 inch high partition was centered on the platform to separate S from the experimenter (E). A one-way vision screen within the partition allowed E to observe S. Positioned above the one-way screen was a 20 watt fluorescent lamp which illuminated S's side of the apparatus.

The stimuli for each problem were selected from a pool of 25 stimuli consisting of all combinations of five colors (red, yellow, purple, brown and green) and five forms (triangle, T, circle, cross and square). Each stimulus consisted of a 2-inch, two-dimensional, color-form pattern centered on a 3 1/2 in.^{2} white background. The stimuli were presented to S mounted on plastic display wedges.

TABLE I

MEAN AND RANGE OF CHRONOLOGICAL AGES FOR Ss IN MAIN EXPERIMENTAL CONDITIONS

Condition			Mean	Range
Training		Transfer		
50-50	-	50-50	8-8	7-4 to 10-9
75-25	-	75-25:25	9-2	7-8 to 10-7
75-25	-	75-25:75	8-11	7-8 to 10-3
90-10	-	90-10:10	8-5	7-6 to 9-10
90-10	-	90-10:90	8-9	7-7 to 10-1

General Procedure

S was brought into a small experimental room, seated before the WGTA, and given prepared instructions (see Appendix A). In general, S was told he was to play a game with E in which he was to try to find out whether a white poker chip was hidden under the right or left stimulus wedge. He was told that when he found the poker chip he could keep it until the game was over and then trade all of his poker chips in for a prize. The prizes, which consisted of dime store items such as marbles, clay, crayons, etc., were shown to S before the game started. A training problem was given S until a learning criterion of 18 correct responses out of a block of 20 trials was reached, or until S failed to reach criterion on each of four successive days. If

S reached criterion on the training problem he was given a transfer problem the following day. The same learning criterion applied to the transfer problem. Two blocks of 20 trials each were presented S each day unless learning criterion was reached within the first block of trials. A trial consisted of E pushing the stimulus tray toward S and allowing S to choose one of the two stimuli. If the correct stimulus was chosen the response was reinforced by the poker chip and by E saying "good" or "very good." If the response was incorrect E said "no" and S was allowed to correct his choice and thus receive a poker chip.

Experimental Design

Training Conditions - Twenty Ss were randomly assigned to each of the three training conditions: 90-10, 75-25, and 50-50. Ten Ss in each training conditioning were given a form relevant, color partially relevant, problem, and ten Ss were given a color relevant, form partially relevant problem, with the exception that the 50-50 group received a variable irrelevant nonreference dimension. Stimuli were randomly assigned to each S.

The three training conditions differed in the degree of correlation of the nonreference dimension with the reference dimension (see Figure 1).

1. 90-10 Condition - a given cue (s_2) of the nonreference dimension was associated on 90 per cent of the trials with the positive cue (s_1) of the reference dimension; s_2 was associated with the negative cue (s_1') of the reference dimension on 10 per cent of the trials. The other cue (s_2') of the nonreference dimension was associated with s_1 on 10 per cent of

the trials and with s_1' on 90 per cent of the trials.

2. 75-25 Condition - s_2 was associated with s_1 on 75 per cent of the trials and with s_1' on 25 per cent of the trials; likewise s_2' and s_1' were presented together on 75 per cent of the trials, with s_2' and s_1 being presented together on 25 per cent of the trials.

3. 50-50 Condition - a given cue of the nonreference dimension was paired with one cue of the reference dimension 50 per cent of the time and with the other cue of the reference dimension 50 per cent of the time. This was accomplished by superimposing one Gellermann series on another. In effect, the nonreference dimension was a variable irrelevant dimension.

Transfer Conditions: Upon reaching acquisition criterion on the training problem *S*s were given a transfer problem in which the nonreference dimension of the training problem became the reference dimension and the reference dimension of the training problem became variable and irrelevant with two new cue values. New cues of the previous reference dimension were used in order to avoid having the old cues dominate transfer performance and thereby mask the desired transfer effects.

1. 90-10:90 - the positive cue in transfer was the cue that had been associated with reward on 90 per cent of the training trials, and the negative cue in transfer had been associated with reward on 10 per cent of the training trials. (N=10)

2. 90-10:10 - the positive cue of the transfer problem had been rewarded 10 per cent of the time in training, and the negative cue of the transfer problem had been rewarded 90 per cent of the time in training. (N=10)

3. 75-25:75 - the cue associated with reward on 75 per cent of the training trials was always rewarded in transfer, and the cue associated with reward on 25 per cent of the training trials was never rewarded. (N=10)

4. 75-25:25 - the cue rewarded 25 per cent of the time in training was always rewarded in transfer, and the cue rewarded 75 per cent of the time in training was never rewarded. (N=10)

5. 50-50 Transfer - the **S**s of the 50-50 training group were given a straight extradimensional shift in which the original irrelevant dimension became relevant and the original relevant dimension became variable and irrelevant. Since all **S**s were treated in the same manner, that is the group was not subdivided as were the other two transfer groups, this group was essentially a control group for the transfer problem. (N=20)

Position cues in both training and transfer were distributed according to the Gellermann series (Gellermann, 1933). Table II presents the overall design of the experiment and Table III illustrates a sample sequence of problems for the 90-10 training and both of the 90-10 transfer groups.

TABLE II

ILLUSTRATION OF EXPERIMENTAL DESIGN
FOR TRAINING AND TRANSFER STAGES

Training Stage

Training Condition (A)

Dimension (B)	A_1 50-50	A_2 75-25	A_3 90-10
B_1 Color			
B_2 Form			

Transfer Stage

Transfer Condition

C 50-50	A_1 75-25	A_2 90-10	Cue Correlation
Control	75-25:75 (A_1B_1)	90-10:90 (A_2B_1)	High B_1
	75-25:25 (A_1B_2)	90-10:10 (A_2B_2)	Low B_2

TABLE III

ILLUSTRATION OF A SEQUENCE OF TRAINING AND TRANSFER PROBLEMS FOR A FORM RELEVANT, COLOR PARTIALLY CORRELATED 90-10 CONDITION

Training Stage

90-10 Condition

Reference Dimension = Form (F)

Nonreference (Partially Correlated) Dimension = Color (C)

Positive Cue*	Negative Cue
C_1F_1 - 90%	C_2F_2 - 90%
C_2F_1 - 10%	C_1F_2 - 10%

Transfer Stage

Reference (Relevant) Dimension = Color

Nonreference (Variable and Irrelevant) Dimension = Form

90-10:90 Condition			90-10:10 Condition		
	Positive Cue	Negative Cue		Positive Cue	Negative Cue
Trial 1	C_1F_3	C_2F_4	Trial 1	C_2F_3	C_1F_4
Trial 2	C_1F_4	C_2F_3	Trial 2	C_2F_4	C_1F_3

* Different Subscripts Indicate Different Cues

CHAPTER IV

RESULTS

The results will be presented first for the training stage and then for the transfer stage. The dependent measure for all analyses was number of errors. An error was recorded when S chose the stimulus containing the negative cue of the reference dimension.

Training Stage

A training condition x dimension x trials analysis of variance (AOV) was done on the number of errors made to criterion performance in training. The results are given in Table IV.

TABLE IV

ANALYSIS OF VARIANCE FOR NUMBER OF ERRORS MADE TO CRITERION IN TRAINING

Source of Variation	df	MS	F	
Between Subjects	59			
A (Training Condition)	2	34.85729	3.225	$p < .05$
B (Dimension)	1	19.26667	1.783	
AB	2	9.92605	.918	
Subjects in Groups (Error Between)	54	10.80718		
Within Subjects	900			
C (Trials)	15	92.64444	57.852	$p < .01$
AC	30	2.43507	1.515	
BC	15	2.16445	1.350	
ABC	30	1.15715	.720	
C x Ss in Groups (Error Within)	810	1.60693		

The mean number of errors for the color dimension was 18.00 and the mean number of errors for the form dimension was 13.47. The difference was not statistically significant. Training condition (factor A) was significant at beyond the .05 level of confidence. The mean number of errors for the 50-50, 75-25, and 90-10 conditions was 21.15, 15.45, and 10.60, respectively. The Newman-Keuls method of making individual comparisons was used to test the difference between these training conditions. Table V presents the results of these comparisons. As the data indicate, the order of difficulty from most to least difficult was 50-50, 75-25, and 90-10, with each group being significantly different from each of the other two groups. This ordering can be seen in Figure 2 which plots learning curves for each of the training conditions collapsed across dimensions. The significant trials effect (factor C) merely reflects the fact that Ss learned the problem. No interactions with trials were revealed in the analysis.

TABLE V

INDIVIDUAL COMPARISONS FOR TRAINING CONDITIONS USING THE NEWMAN-KEULS PROCEDURE

Comparison	Error Difference	q Value	
$a_1 - a_2$	114	7.76	$p < .01$
$a_1 - a_3$	211	14.35	$p < .01$
$a_2 - a_3$	97	6.59	$p < .01$

a_1 = 50-50 = 423 errors
a_2 = 75-25 = 309 errors
a_3 = 90-10 = 212 errors

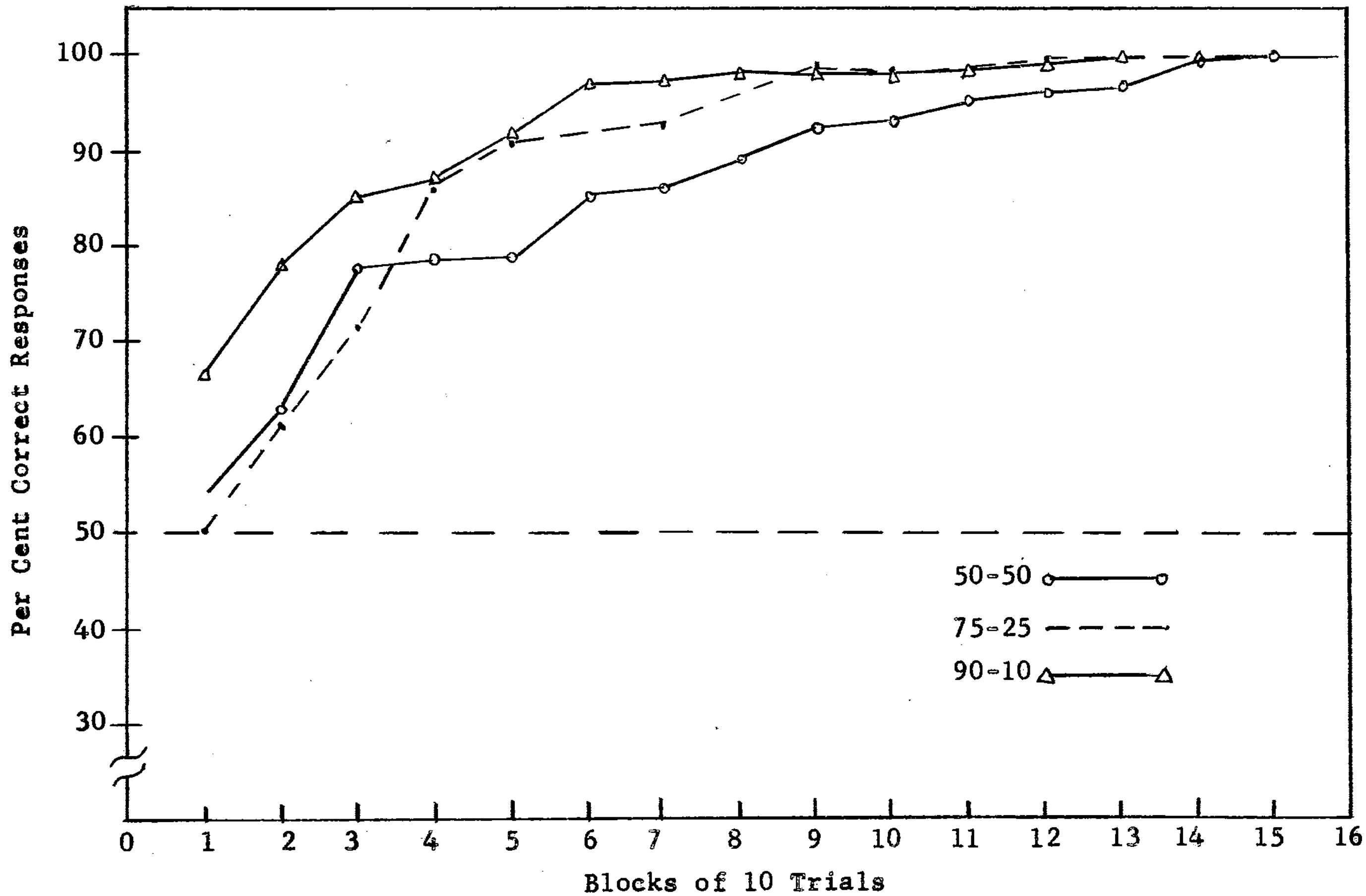

Figure 2. Learning Curves for Training Conditions Collapsed Over Dimensions

Transfer Stage

An overall analysis of variance was performed on the number of errors made during transfer. The design of the analysis followed one presented by Winer (1962, p. 263). The 50-50 transfer condition was considered to be a control group since all Ss in this condition were treated alike; that is, the 50-50 transfer condition was not subdivided as were the 75-25 and 90-10 transfer groups. The rest of the analysis was a 2 x 2 factorial with factor A being the condition under which Ss were trained and factor B the degree of correlation between the positive cue of the transfer problem and reward during training (see Table II). This design allows for the testing of the two factors and their interaction plus comparing the control group with all other conditions combined. Table VI summarizes the analysis.

TABLE VI

ANALYSIS OF VARIANCE FOR ERRORS MADE IN TRANSFER STAGE

Source of Variation	df	MS	F
Control vs. All Others	1	38.72000	
A (Training Condition)	1	96.10000	
B (Cue Correlation)	1	.90000	
AB	1	504.10000	.786
Within Cell	55	641.15182	

As the table indicates none of the results approached significance. Likewise, none of the individual experimental groups were significantly different from the control group. The largest difference was between the control group (mean errors = 16.45) and the 90-10:90 group (mean errors = 9.5). The *t* value for the difference between these means is .785 (tab. $\underline{t}_{(.05)(5,55)} = 2.41$). Since this was the largest difference no other comparisons were made between the control group and other individual groups. A single classification AOV was run comparing the 50-50, 75-25:75 and 90-10:90 groups. The resulting F value of .302 was not significant. Similarly, an AOV comparing the 50-50, 75-25:25 and 90-10:10 groups was not significant (F=.103). Figure 3 presents learning curves for the overall transfer conditions collapsed over cue correlation.

In order to investigate more thoroughly the course of learning in transfer the 75-25:75 condition was plotted against the 75-25:25 condition, and the 90-10:90 condition was plotted against the 90-10:10 condition. These curves are presented in Figures 4 and 5. Initial inspection of Figure 4 suggested that the course of learning was essentially the same for the 75-25:75 and 75-25:25 conditions. However, Figure 5 suggested that the 90-10:90 group learned much faster than the 90-10:10 group on the first day of transfer (first 40 trials).

A conditions (cue-correlation) x trials analysis of variance was computed on the number of errors made in transfer for both the 75-25 and the 90-10 transfer groups. Table VII presents the AOV for the 75-25 condition and Table VIII the AOV for the 90-10 condition. The only significant result for the 75-25 AOV was the trials factor, indicating a significant decrease in errors over trials. However, the 90-10 AOV shows not only a significant trials factor but also a significant cue-correlation x trials interaction. This reflects the difference shown in Figure 5 in which the Ss in the 90-10:90 group learned much faster than those in the 90-10:10 group.

The mean number of errors in the first 40 trials for the 75-25:75

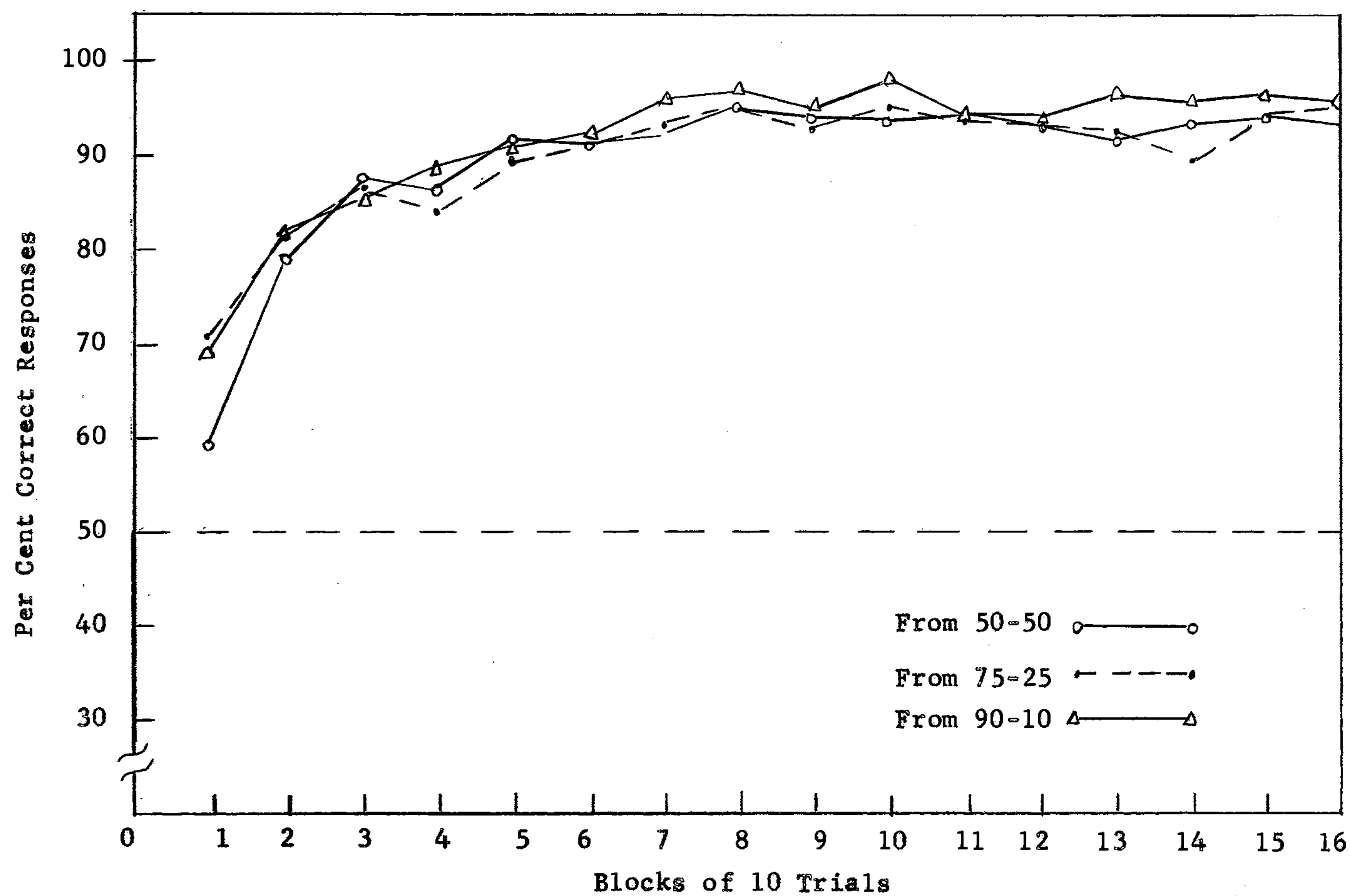

Figure 3. Learning Curves for Transfer Conditions Collpased Over Cue Correlation

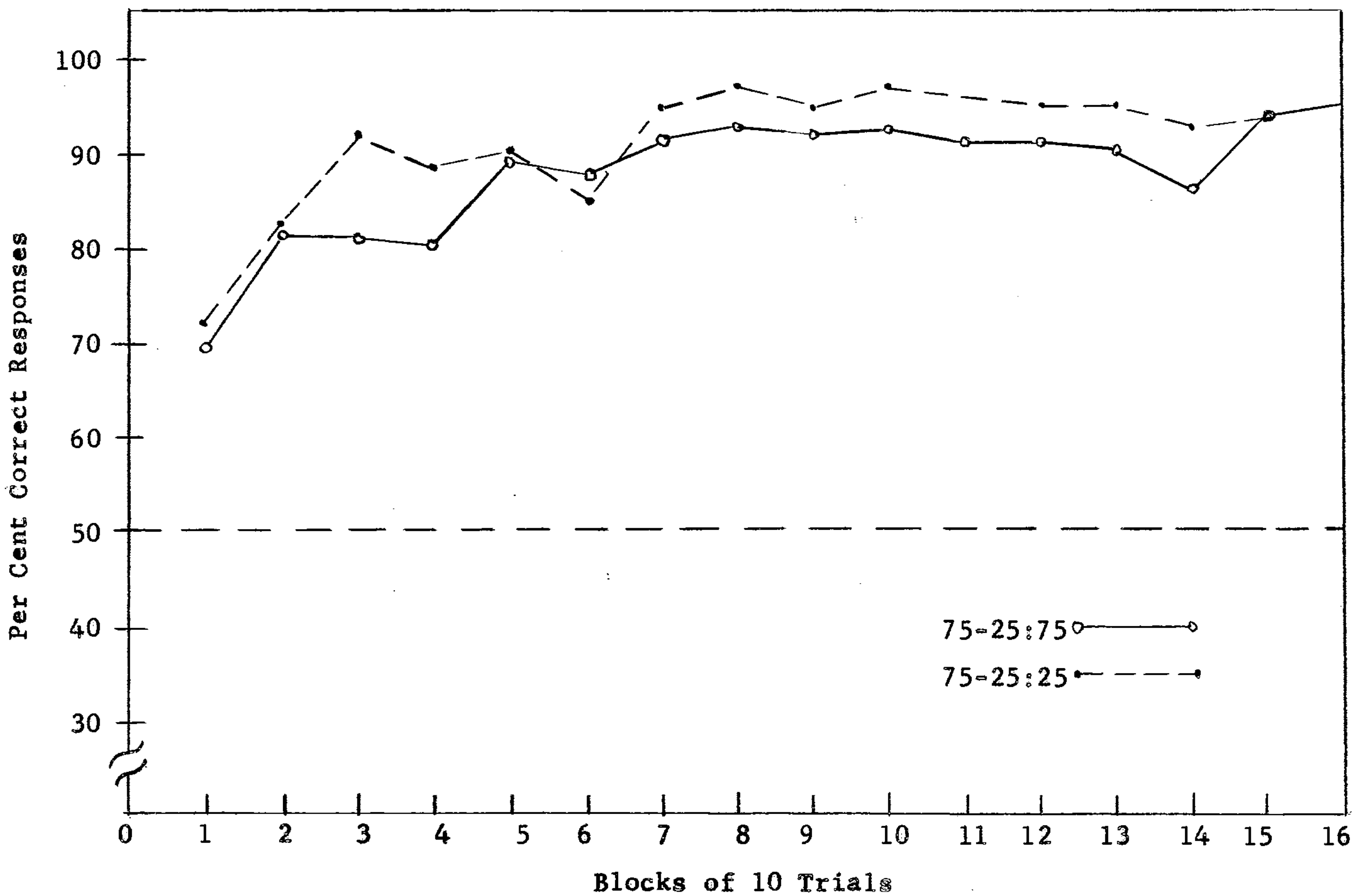

Figure 4. Learning Curves for 75-25:75 and 75-25:25 Transfer Conditions

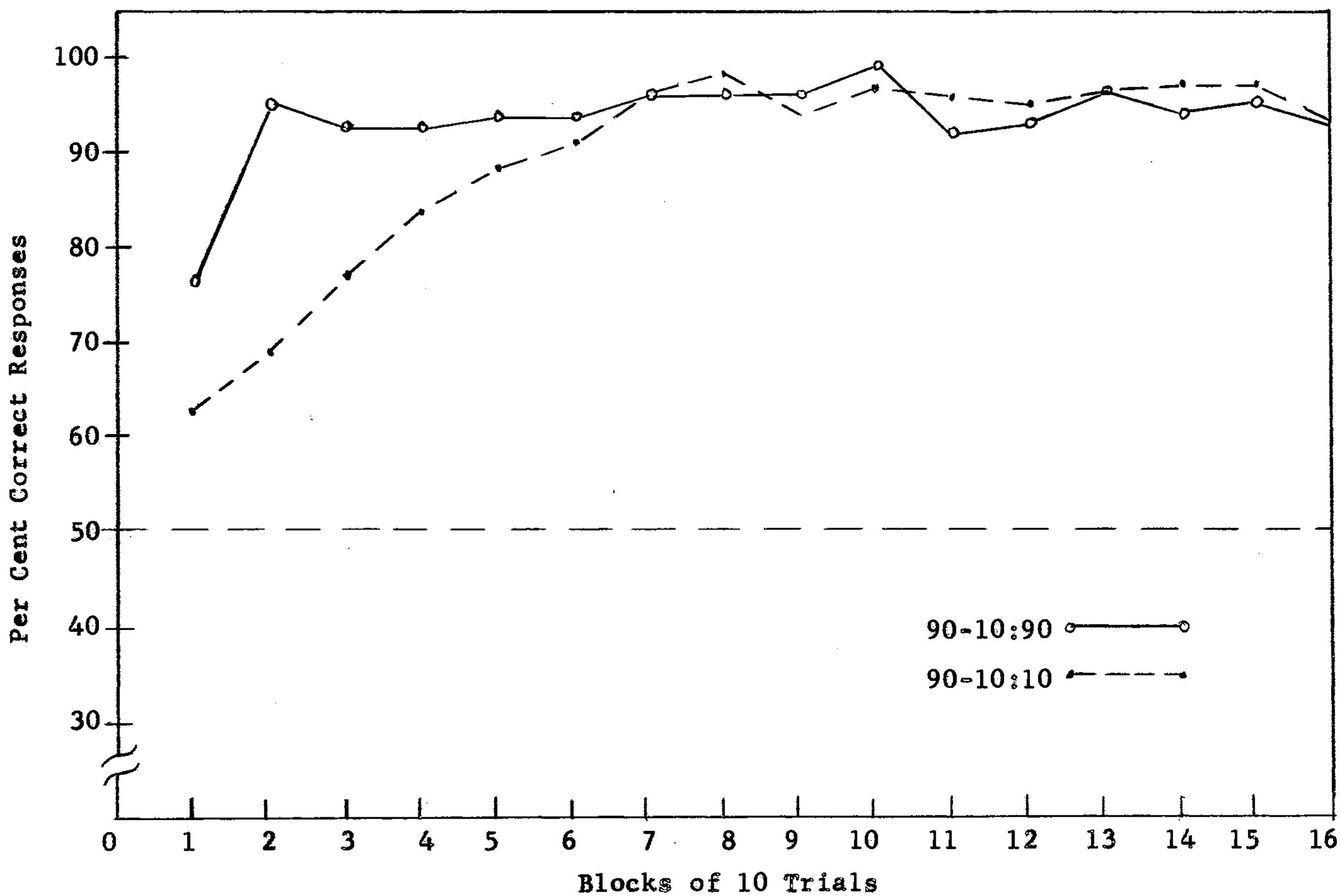

Figure 5. Learning Curves for 90-10:90 and 90-10:10 Transfer Conditions

TABLE VII

ANALYSIS OF VARIANCE FOR NUMBER OF ERRORS MADE IN 75-25 TRANSFER CONDITION

Source of Variation	df	MS	F	
Between Subjects	19			
A (Cue Correlation)	1	14.02812	.287	
Subjects Within Groups	18	48.88229		
Within Subjects	300			
B (Trials)	15	8.48646	7.344	$p < .01$
AB	15	.50813	.440	
B x Ss in Groups	270	1.15563		

TABLE VIII

ANALYSIS OF VARIANCE FOR NUMBER OF ERRORS MADE IN 90-10 TRANSFER CONDITION

Source of Variation	df	MS	F	
Between Subjects	19			
A (Cue Correlation)	1	16.65312	.554	
Subjects Within Groups	18	30.05590		
Within Subjects	300			
B (Trials)	15	10.91979	9.228	$p < .01$
AB	15	3.72646	3.149	$p < .01$
B x Ss in Groups	270	1.18331		

condition was 8.9, and for the 75-25:25 condition the mean was 6.6. The difference between these means was not statistically significant (t=.61). For the 90-10:90 condition the mean number of errors in the first 40 trials was 3.7, and for the 90-10:10 condition the mean was 10.8. The t value for the difference between these means is 2.140, which is significant at beyond the .05 level of confidence for a two-tailed test (tab. $t_{(.05)(18)} = 2.101$).

To summarize, the only significant difference in transfer was between the performance of the 90-10:90 group and the 90-10:10 group on the first day of transfer, when the 90-10:90 group learned significantly faster than the 90-10:10 group.

CHAPTER V

DISCUSSION

The study was not designed as a test of any particular theoretical position, although it does have some theoretical implications. An attempt will be made to discuss the results in light of three general approaches: noncontinuity, continuity, and modified noncontinuity theory.

Noncontinuity Theory

Training stage - The major finding from the training-stage data was an inverse relationship between the number of errors to criterion and the degree of correlation of the nonreference dimension with the reference dimension. Such a relationship would seem to pose some problems for strict noncontinuity theory, especially if noncontinuity theory is interpreted as saying that an organism attends only to one dimension of a problem at a time while learning nothing about the significance of other dimensions (see Mackintosh, 1965). In order for Ss to have reached criterion performance in training they had to at least be responding to the cues of the reference dimension. According to noncontinuity theory the fact that they learned to solve the problem on the basis of the reference dimension should prevent their learning anything about the significance or degree of correlation of the nonreference dimension. Therefore, the degree of correlation of the nonreference dimension should not have differentially affected training stage performance.

<u>Transfer stage</u> - In transfer the 90-10:90 group made significantly fewer errors than the 90-10:10 group. The positive cue of the 90-10:90 problem was the cue (s_2) of the nonreference dimension in training that had been associated with reinforcement 90 per cent of the time. The positive cue (s_2') of the 90-10:10 group had been associated with reward 10 per cent of the time in training. This difference is not easily handled by noncontinuity theory. If <u>S</u> had learned nothing about the significance of the nonreference dimension in training there should have been no initial cue preference in transfer. Therefore, no difference would be expected between the 90-10:90 and 90-10:10 groups. It is possible, however, for <u>S</u>s in the 90-10 training group to have reached the 90 per cent learning criterion by attending only to the nonreference dimension. If such were the case, noncontinuity theory would predict superior performance of the 90-10:90 group over the 90-10:10 group. On the other hand, if it is assumed that <u>S</u>s attended only to the nonreference dimension in training it is difficult to explain the differences among the 50-50, 75-25, and 90-10 training conditions. <u>S</u>s in the 50-50 and 75-25 training conditions most likely would not have reached criterion performance.

Continuity Theory

A Hull-Spence type continuity theory does not limit <u>S</u>'s response to only a portion of the stimulus complex, but assumes rather that all aspects of the stimulus impinging upon the senses will be equally responded to by <u>S</u>. Thus, approach tendencies should be conditioned to all stimuli associated with reward on a given trial, so that not only cues of the reference dimension but also cues of the nonreference dimension should have approach tendencies conditioned to them.

Training stage - If cues of the nonreference dimension have been differentially reinforced they should have an effect on performance. Stronger approach tendencies should have been conditioned to the more frequently reinforced cue of the nonreference dimension (s_2) than to the less frequently reinforced cue (s_2'). When s_2 is associated with s_1 (of the reference dimension) the approach tendencies to the two cues should summate and the total should be much larger than when s_2' is associated with s_1 . The higher the correlation of the nonreference dimension, the more often s_1 and s_2 appear together, and the less likely should be the tendency for S to choose the negative stimulus. Therefore, as the correlation between the nonreference dimension and the reference dimension increases, the number of errors made in training should decrease, which was the indication from the present study.

Transfer stage - The superiority of the 90-10:90 group over the 90-10:10 group is easily handled by continuity theory. Since it is assumed that S learns about the cues of the nonreference dimension as well as those of reference dimension, stronger approach tendencies should have been conditioned to s_2 than to s_2' during training; and since s_2 is positive in a 90-10:90 transfer problem and negative in a 90-10:10 problem, performance should be superior for the 90-10:90 group.

No significant difference was found in transfer between the 75-25:75 and 75-25:25 groups. Failure to find a difference here is not easily accounted for as it is not consistent with other results of the study and also is not consistent with similar rat research. For example, in two experiments Bitterman and Coate (1950) found differences between 80-20:80 and 80-20:20 groups. Also, Jeeves and North (1956) and Hughes and North (1959) both found differences between 75-25:75 and 75-25:25 groups. These studies were interpreted as supporting continuity theory over noncontinuity theory (see Chapter II).

Finding no difference between the 75-25:75 and 75-25:25 groups might initially be interpreted as indicating that the 75-25 correlation in training was not high enough to affect differential approach tendencies to the two cues of the nonreference dimension. However, the fact that performance in training for the 75-25 group was superior to that of the 50-50 group seems to refute such an interpretation. Perhaps the transfer problem was not sensitive enough to pick up differences in approach tendencies that were conditioned in training to the cues of the nonreference dimension.

Modified Noncontinuity Theory

In recent years considerable interest has developed around several two-stage theories of discrimination learning. In general, these theories postulate that discrimination learning involves two processes; first, an attentional response is made to a dimension (or dimensions) of a problem, and then an instrumental response is made to a cue (or cues) of the dimension. Goodwin and Lawrence (1955), Sutherland (1959), and Zeaman and House (1963) have all outlined somewhat similar two-stage models.

Mackintosh (1965) has termed these two-stage theories *modified noncontinuity theory*, as they represent an alternative to the two extremes of straight noncontinuity theory at one end and continuity theory at the other. According to modified noncontinuity theory an organism is not limited to learning only about one dimension at a time nor is it the case that it learns equally about all dimensions at the same time. Instead the organism can learn about both Dimension A and Dimension B at the same time, yet it might learn more about Dimension A than Dimension B. Mackintosh states, ". . . animals do not classify their stimulus input with equal effectiveness in all possible ways at once, and it should therefore be possible to influence what an animal attends to by appropriate training procedures." (1965, p. 130) He further adds, "Thus attention to one cue does not prevent an animal learning anything about a second cue, but it does reduce the amount learned." (p. 131) Here Mackintosh is using "cue" with the same meaning as "dimension" is used in the present discussion.

Training stage - It is difficult to make specific predictions about the relative performance of the 50-50, 75-25 and 90-10 training conditions if one is restricted to Mackintosh's general presentation of modified noncontinuity theory. However, Zeaman and House (1963) have formalized their version of modified noncontinuity theory by developing a mathematical learning model which predicts performance on problems involving a partially correlated nonreference dimension. Using the "Monte Carlo" method of applying the operators in their model they have generated a few stat-children (N = 20) functions over 200 learning trials. Stat-children are simply statistical creatures which behave according to the rules of the probability model. Some of the functions would appear to be relevant to the present study although it should be noted that these stat-children were on a partial reinforcement schedule for the reference dimension rather than the continuous schedule that the grade school children were on.

An interesting feature of the Zeaman and House computer data was that no difference was revealed between a 50-50 condition and a 75-25 condition. This is in contrast to the present study where a significant difference was found between the 50-50 and 75-25 groups. The performance of the stat-children did increase considerably when the correlation of the nonreference dimension increased from 75-25 to 100-0, or, in other words, when two completely relevant dimensions were present. In a similar manner, increasing the correlation of the nonreference dimension in the present study from 75-25 to 90-10 resulted in a significant increase in performance.

Zeaman and House (1963, p. 208) give a verbal translation of their model as follows: "the correct (reference) stimulus will be lifted if the subject looks at the correct dimension and approaches the correct cue, _or_ if he looks at one of the nonreference dimensions and approaches one of the cues s_i which is associated with the correct stimulus, _or_ if he looks at one of the nonreference dimensions and approaches the other cue s_i' which is associated with the correct stimulus." This model can be described as a _one-look_ model because **S** looks at only one dimension on each trial--in this case either the reference or the nonreference dimension. If, however, it is assumed that **S** can observe both the reference _and_ the nonreference dimension on the same trial the model becomes a _two-look_ model.

In situations where only two dimensions are manipulated, as was the case in the current study, a two-look model should generate essentially the same predictions as continuity theory. If **S** is looking at both dimensions on each trial then approach tendencies should be conditioned to the cues of both dimensions on each trial. Thus a two-look version of modified noncontinuity theory should be able to handle the results of the training stage in much the same manner as straight continuity theory.

Transfer stage - If Ss are responding to the training problem in accordance with the assumptions of a one-look model it follows that the probability of observing a given dimension must approach 1.0 and the probability of observing all other dimensions must be almost 0.0. If Ss have solved the training problem by observing the reference dimension the probability of observing the nonreference dimension should approach 0.0. Assuming that the strength of the instrumental responses to the cues of the nonreference dimension extinguish along with observing response, there should be no differential approach tendencies to the cues of the nonreference dimension at the beginning of transfer and this should be indicated by equal performance of the 90-10:90 and 90-10:10 groups.

Therefore, if the difference between the 90-10:90 and 90-10:10 groups is to be accounted for by a one-look model it must be assumed that Ss were observing the nonreference dimension during training, which would allow them to reach the 90 per cent learning criterion. The 90-10:90 condition would then result in positive transfer of both the observing and instrumental responses. In contrast, the 90-10:10 condition would involve negative transfer of the instrumental responses since the more frequently reinforced cue of the training problem becomes the negative cue of the transfer problem and the less frequently reinforced cue in training becomes positive in transfer. This should result in superior performance of the 90-10:90 group over the 90-10:10 group.

A two-look model should be able to account for the 90-10:90-90-10:10 difference with little difficulty. If S observes the nonreference as well as the reference dimension on each training trial the strength of the instrumental response to s_2 should be greater than the strength of the instrumental response to s_2'. Thus, in the first part of transfer the 90-10:90 group would be expected to perform better than the 90-10:10 group.

The failure to find a difference between the 75-25:75 and 75-25:25 groups would be consistent with predictions based on a one-look model. However, a two-look model might also be able to handle these results, provided some *ad hoc* assumptions are made about the learning process in this situation. Zeaman and House (1963) have constructed a two-look model whereby S can observe either one dimension or two dimensions on a given trial. Thus, if Ss in the 75-25 condition had learned to attend to only one dimension instead of two, the prediction for the 75-25 transfer condition would be identical to that made with a one-look model--that is, no difference would be expected between the 75-25:75 and 75-25:25 groups. However, the fact that in training the 75-25 group differed in performance from the 50-50 and 90-10 groups indicates that performance was being affected by both the reference and nonreference dimension.

Future Research

Due to subject limitations no 100-0 condition (two relevant dimensions) was included in the present study. It would be interesting to compare the performance of such a group with that of the other groups in the study, especially the 90-10 group. It is quite possible that a 100-0 group would not differ significantly from a 90-10 group.

Probably the major discrepancy in the present study, relative to a continuity theory interpretation and to rat research in the area, was the failure to find a difference in transfer between the 75-25:75 and 75-25:25 groups. A replication of at least this particular part of the study would seem advisable.

It is, of course, quite possible to design a problem with more than one partially correlated nonreference dimension. If two nonreference dimensions were used several interesting designs would be possible. For example, consider the following design which has one relevant dimension and two 80-20 partially correlated dimensions.

TABLE IX

PROPOSED DESIGN FOR INVESTIGATING THE EFFECT OF ONE VERSUS TWO PARTIALLY CORRELATED NONREFERENCE DIMENSIONS

	Training			Transfer							
				<u>A</u>		<u>B</u>		<u>C</u>		<u>D</u>	
				(+)	(-)	(+)	(-)	(+)	(-)	(+)	(-)
Group I	Color:	s_1 100	s_1' 0	$s_2 s_3$	$s_2' s_3'$	$s_2' s_3'$	$s_2 s_3$	s_2	s_2'	s_2'	s_2
	Form:	s_2 80	s_2' 20								
	Size:	s_3 80	s_3' 20								
				<u>A</u>		<u>B</u>		<u>C</u>		<u>D</u>	
				(+)	(-)	(+)	(-)	(+)	(-)	(+)	(-)
Group II	Color:	s_1 100	s_1' 0	$s_2 s_3$	$s_2' s_3'$	$s_2' s_3'$	$s_2 s_3$	s_2	s_2'	s_2'	s_2
	Form:	s_2 80	s_2' 20								
	Size:	s_3 50	s_3' 50								

This design would provide for an investigation of the effect of one versus two partially correlated dimensions in training and transfer.

Training Group I is presented a problem with two 80-20 partially correlated nonreference dimensions; Group II has one 80-20 and one 50-50 nonreference dimension. In transfer conditions A and B both of the nonreference dimensions of the training problem are completely relevant. The more frequently reinforced cues from training are positive in Group A and the less frequently reinforced cues are positive in Group B. In transfer conditions C and D only one of the nonreference dimensions from training becomes relevant. Comparing the two training groups would estimate the effect of increasing the number of partially correlated dimensions from one to two. A comparison of A with C, and B with D should contrast the effect of making two previous nonreference dimensions relevant in transfer against the effect of making one nonreference dimension relevant in transfer.

Another possible design involves the manipulation of transfer of attentional and instrumental responses. The design of the present study provided for the transfer from training of both attentional responses to the partially correlated (nonreference) dimension and instrumental responses to the cues of the nonreference dimension; that is, the nonreference dimension in training was relevant in transfer and the cues of the nonreference dimension in training were carried over to transfer. However, if new cues of the previous nonreference dimension were introduced in transfer, only the attentional response would transfer from training. For example, consider the design on the following page.

The 50-50 and 90-10 training conditions, and the ED (extradimensional) shift and 90-10:90 transfer conditions would be identical to those used in the current study. However, in the 90-10:New condition new cues of the previous nonreference dimension are introduced in transfer. Differences between the ED shift and 90-10:New condition would be attributed to the fact that the 90-10:New group had a partially correlated dimension in training. Any difference between the 90-10:90 and 90-10:New conditions should be due to the fact that the 90-10:90 group transferred both attentional and instrumental responses from training whereas the 90-10:New group transferred only the attentional response.

Training	Transfer
50-50 Color Relevant Form Irrelevant	ED Shift (Form Relevant)
90-10 Color Relevant Form Partially Correlated	90-10:90 90-10:New

CHAPTER VI

SUMMARY AND CONCLUSIONS

The purpose of the present study was to investigate the effect of a partially correlated dimension upon discrimination learning in children. Sixty normal grade school children were used as Ss.

The study involved two stages. In the training stage Ss were presented a two-choice problem in which one dimension (reference) was completely relevant and a second dimension (nonreference) was only partially correlated with the reference dimension and reward. The three basic training conditions differed in the degree of correlation of the nonreference dimension: (1) 50-50 Condition - the cues of the nonreference dimension were randomly correlated with reward and the cues of the reference dimension; (2) 75-25 Condition - one cue of the nonreference dimension (s_2) was associated with the positive cue (s_1) of the reference dimension 75 per cent of the time, and the other cue of the nonreference dimension (s_2') was associated with s_1 25 per cent of the time; (3) 90-10 Condition - cue s_2 was associated with s_1 90 per cent of the time, and s_2' was associated with s_1 10 per cent of the time.

In the transfer stage Ss were presented a problem in which the nonreference dimension of the training stage became completely relevant, and the reference dimension of the training stage became variable and irrelevant. There were five basic transfer groups:

(1) 50-50 - Ss received a straight extradimensional shift from the 50-50 training stage; (2) 75-25:75 - the positive cue in transfer was the cue that had been associated with reward 75 per cent of the time in training; (3) 75-25:25 - the positive cue of transfer had been associated with reward 25 per cent of the time in training; (4) 90-10:90 - the positive cue in transfer had been associated with reward 90 per cent of the time in training; (5) 90-10:10 - the positive cue in transfer had been associated with reward 10 per cent of the time in training.

Data from the training stage revealed an inverse relationship between the number of errors to criterion and the degree of correlation of the nonreference dimension. The performance of each training group differed significantly from the performance of each of the other two groups.

In transfer the major finding was the superior performance of the 90-10:90 group over the 90-10:10 group. The difference was most pronounced in the first 40 trials of transfer. No difference was found between the 75-25:75 and 75-25:25 groups.

In general the results indicated that a partially correlated dimension did have an effect upon the learning of a two-choice discrimination problem by grade school children. The findings were discussed in relation to three general theoretical approaches--noncontinuity, continuity and modified noncontinuity theory. It was concluded that continuity theory can more easily handle the data than can noncontinuity theory. It was also concluded that the incorporation of a two-look assumption for modified noncontinuity theory should make it possible for modified noncontinuity to account for the major findings of the study.

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APPENDIX A

INSTRUCTIONS

I have a game I would like to play with you. Let me show you how to play. When I push this tray out you see if you can find the white disk. It will be hidden here (left) or here (right). When you find the white disk you may put it in your sack. When you have enough white disks you may trade them for one of these prizes. Let's try it once.

VITA

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