TACTUAL-KINESTHETIC DISCRIMINATION LEARNING
IN RETARDED CHILDREN

By

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CHAPTER I

INTRODUCTION

The majority of the research in retardate discrimination learning has utilized the visual modality. Discrimination learning studies involving other subject populations have also been primarily concerned with the visual sense (Kimble, 1961). It is the purpose of the present study to determine if findings and theory of retardate discrimination learning will generalize to a different sense modality.

This study compares the discriminative processes of the retardate in the tactual-kinesthetic modality. Other terms have been used to describe this type of discrimination including haptic discrimination (Piaget, 1956) and astereognosis, a neurological classification (Ross, 1954). Since S gets information from both tactual and kinesthetic feedback, this terminology was decided upon.

The theoretical foundation of the study is the Attention Theory of Zeaman and House (1963). This theory of retardate discrimination learning is a chaining model which postulates two distinct responses: an observing response and an instrumental response. The observing response is directed to a dimensional property of the stimulus or a broad class of cues having a common discriminative property (e.g., form). The instrumental response is made to a specific cue within the observed dimension (e.g., pyramid).

The probability of observing the relevant dimension (Po_1) may be at any level when the task is first presented, but the probability of making the correct instrumental response (Pr_1) is at a chance level. These two probabilities increase as a consequence of direct reinforcement when the response is made to the positive cue. Po can also grow if the instrumental response is made to a negative cue through the process of indirect acquisition. Indirect acquisition is the process by which the Po of the dimension(s) not responded to will increase in direct proportion to their existing value when the instrumental response is directed to a negative cue. The rate of growth of these two probabilities is unequal with Pr increasing more rapidly than Po. The value of Pr will reach near unity much earlier with Po gradually reaching a similar level if enough trials are given. Po and Pr can be measured only indirectly through the probability of an overt response (P).

Attention Theory makes predictions about three types of transfer or shift problems including reversal, intradimensional (ID), and extradimensional (ED) shifts. A reversal transfer is an operation in which the relevant dimension is maintained in the new problem, but the cues change their value (the previously positive cue becomes negative and vice versa). Here the probability of observing the relevant dimension (Po_1) remains high, but the probability of responding to the relevant cue (Pr_1) is low--the value being the compliment of the prereversal Pr_1. The predicted function is at first negatively accelerated and then levels off at approximately a chance level forming the reversal midplateau, a short period of positive acceleration. It is hypothesized that the plateau is an indication of the fact that the <u>S</u> is discarding his old observing response to the previously relevant dimension. The remainder of the function is negatively accelerated. The presence of a reversal midplateau is a unique prediction of Attention Theory.

The conditions in an ID shift are such that the same dimension is relevant in the transfer problem as in the training problem, but a new set of cues is introduced. If in the training problem, form was the relevant dimension with the specific cues being pyramid and cone, the transfer problem would maintain form relevant but square and sphere would be the new cues. In the terms of Attention Theory, the probability of observing the relevant dimension (Po_1) remains high, but the probability of making a correct instrumental response (Pr_1) drops to a chance level.

The ED shift is an instance of negative transfer as the relevant dimension of the original problem becomes irrelevant for problem solution. If, in the original problem, form was relevant and size irrelevant, size would be the relevant dimension in the shift condition. In this type of transfer, Po_1 drops to a low level and Pr_1 drops to a chance level.

The theory predicts that the ID and reversal shifts should be learned faster than the ED shift, and the reversal performance should fall somewhat below the ID shift performance. This has been supported by data in visual discrimination as shown by Zeaman and House (1963).

Statement of the Problem

The purpose of the present study was to determine the applicability of Attention Theory using a tactual-kinesthetic discrimination task, with form and texture as possible dimensions. The specific aims of the experiment were as follows:

1. To extend the generality of Attention Theory by demonstrating that differences in performance of transfer problems (reversal, ID, and ED shifts) found in the visual modality are also found in the tactual-kinesthetic modality.

2. To investigate the dimensionality of form and texture for tactual-kinesthetic discrimination learning.

3. To determine the relative potency of form and texture in tactual-kinesthetic discrimination (i.e., which of these has a greater initial probability of attracting attention).

4. To investigate the presence of the reversal midplateau.

Review of Literature

While a great deal of data concerning visual discrimination learning in retardates is available (House & Zeaman, 1962; Stevenson, 1963; Zeaman & House, 1963; Denny, 1964), few related studies of tactual-kinesthetic discrimination have been reported. Ross (1954) presented brain-injured and normal _Ss_ with tactile discrimination problems consisting of pairs of form stimuli outlined in tacks. Normal _Ss_ were superior in reporting which pairs were the same or different. Gollin (1960) had normal children and adults tactually compare stimuli (forms outlined in tacks) with a standard and found the adults superior, especially when there were interferents present. In a study by Pick (1965), the _Ss_ (first graders) were given a transfer task to determine if performance is dependent upon learning distinctive features or schema formation and utilization. It was found that discrimination learning was superior when the transfer problem maintained the same relevant dimension of difference as the original problem.

Zeaman and House would predict the results of the above studies. Their theory can account for the fact that Ss of lower MA level have inferior performance relative to Ss of higher MA level but equated for CA (Ross and Gollin studies) in terms of attending to the relevant dimension. The time required to learn to observe the relevant dimension increases with a decrease in MA level; once the relevant dimension is attended to, the rate of learning is the same for all Ss. Attention Theory also accounts for superior performance in those transfers in which the Po can carry over to the new problem, as reported in the Pick study.

Even though the existing findings in tactual-kinesthetic discrimination learning can be accounted for by Attention Theory, there exists a need for more formal study to test Attention Theory specifically. This study was designed to do just this.

CHAPTER II

METHOD

Subjects

A total of 45 Ss (28 males and 17 females) from the Hissom Memorial Center, Sand Springs, Oklahoma, having a mean MA of 7-4 (range 5-3 to 9-9) and a mean CA of 14-10 (range 9-5 to 24-5) were used. Only Ss having no gross motor or neurological defects were used. All Ss had had previous experience in visual discrimination tasks but not tactual-kinesthetic discrimination tasks.

Apparatus

The apparatus employed was a Wisconsin General Test Apparatus described by Zeaman and House (1963) modified for tactual-kinesthetic discrimination. This particular apparatus consisted of a moveable front panel with 2 openings 5 in. in diameter and 12 in. apart into which S could insert his hands. These openings were covered by cloth flaps so that S could not see the stimuli. Each stimulus was mounted on a wedge of ¼ in. X 3½ in. X 4 in. masonite. S responded by displacing the stimulus along a sliding track, uncovering the foodwell originally under the stimulus object. There was a one-way-vision screen above the panel enabling E to observe S.

A total of 24 stimuli were used. There were six geometric, plastic solids one cubic inch in volume (square, sphere, pyramid, cone, rectangle, and cylinder) and four degrees of texture. The plain plastic surface constituted the smooth texture. Coarse sandpaper dots or thin strips of fine sandpaper pasted on the stimuli served as two intermediate degrees of roughness. Foam completely covering the stimulus object constituted the fourth texture.

Procedure

The subjects were divided into two main groups according to the dimension which was relevant during original learning: form relevant (N = 21) and texture relevant (N = 21). These two groups were further split into three shift groups each having an N = 7. The six groups were reversal shift with form relevant (Group A), ID shift with form relevant (Group B), ED shift with form relevant (Group C), reversal shift with texture relevant (Group D), ID shift with texture relevant (Group E), and ED shift with texture relevant (Group F). Table I shows the mean MA and CA and the ranges for each of the six shift groups. The experimental procedure consisted of three stages: pretraining, training, and testing.

Pretraining

All Ss were given the instructions in Appendix A and then given four trials to acquaint them with the procedure. The first trial consisted of S putting his hands through the openings and finding a candy reward (M & M) in one of the uncovered foodwells. On the second trial a junk object was placed over the baited foodwell, and S was

TABLE I

MEAN MENTAL AGE AND MEAN CHRONOLOGICAL AGE AND THEIR RESPECTIVE RANGES FOR THE SIX SHIFT GROUPS

	Group A		Group B		Group C		Group D		Group E		Group F	
	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range
MA	7-7	6-8 to 8-11	7-4	6-0 to 9-4	7-6	6-0 to 9-0	6-11	5-6 to 9-6	7-7	5-3 to 9-9	7-5	5-10 to 9-1
CA	15-6	11-3 to 18-11	17-1	10-6 to 24-5	15-8	13-7 to 17-1	13-4	11-6 to 15-8	13-7	9-5 to 17-9	13-10	9-6 to 17-6

instructed to push it back in order to obtain the candy. The procedure was repeated with the opposite side on the third trial. Another junk object was presented on the fourth trial and S had to make the instrumental response to the previously correct stimulus. Throughout these trials E emphasized that what S touched told him where the candy was.

Training

Groups A, B, and C were given a problem with form relevant and texture irrelevant. The positioning of the positive cue was determined by a Gellermann series (1933), as were the positions of the cues of the irrelevant dimension. The stimuli used for each problem were selected randomly. If pyramid was the positive cue and sphere the negative cue for S, a sample set of trials included smooth pyramid versus striped sphere on trial one, striped pyramid versus smooth sphere on trial two, and smooth pyramid versus striped sphere on trial three. Groups D, E, and F were given a problem with texture relevant and form irrelevant. A similar problem was presented as explained above with texture as the relevant dimension.

A total of 25 trials was given per day. The criterion was 20 correct responses out of 25; if S did not meet criterion within 150 trials, he was dropped. Correction procedure was used throughout.

Testing

After training criterion was reached, each of the Ss was given a shift problem. For all three shift conditions, the cues of the irrelevant dimension and the position of the relevant cues were varied according to the Gellermann series. Groups A and D were given a reversal shift. If the original learning problem had pyramid as the positive cue and sphere as the negative cue; Group A had sphere as the positive cue and pyramid as the negative cue in the reversal condition. A series of trials included smooth sphere versus striped pyramid on trial one, striped sphere versus smooth pyramid on trial two, and striped sphere versus smooth pyramid on trial three. A similar problem was given to Group D; for example, if the smooth texture was positive and striped negative during original learning, the striped texture was positive in the reversal problem.

The ID shift condition involved the substitution of two new cues in the relevant dimension. An S in Group B having form relevant with sphere and pyramid being the cues during original learning was presented with two new cues (e.g., cone and cylinder). With cone being the positive cue, trial one had striped cone versus smooth cylinder, trial two - smooth cone versus striped cylinder, and trial three - striped cone versus smooth cylinder. Group E had foam and dotted texture cues substituted for the striped and smooth texture cues used in original learning.

For Groups C and F, the previously relevant dimension became irrelevant in the ED shift problem. For example, texture was the new relevant dimension for Group C and form the relevant dimension for Group F. Group C was given a series of trials with the smooth texture positive and the striped texture negative, e.g., smooth sphere versus striped pyramid on trial one, smooth pyramid versus striped sphere on trial two, and smooth pyramid versus striped sphere on trial three.

A total of 25 trials per session was given. If S did not meet this within 250 trials, he was dropped. Tables II and III illustrate sample problems for the shift groups having either form or texture relevant during original learning.

TABLE II

SAMPLE PROBLEM FOR ORIGINAL LEARNING

AND TRANSFER WITH FORM RELEVANT

Trial Number	Original Learning (Form Relevant)		Reversal Shift (Group A)		ID Shift (Group B)		ED Shift (Group C)	
	+	-	+	-	+	-	+	-
1	Smooth Pyramid	Striped Sphere	Smooth Sphere	Striped Pyramid	Striped Cone	Smooth Cylinder	Smooth Sphere	Striped Pyramid
	+	-	+	-	+	-	+	-
2	Striped Pyramid	Smooth Sphere	Striped Sphere	Smooth Pyramid	Smooth Cone	Striped Cylinder	Smooth Pyramid	Striped Sphere
	+	-	+	-	+	-	+	-
3	Smooth Pyramid	Striped Sphere	Striped Sphere	Smooth Pyramid	Striped Cone	Smooth Cylinder	Smooth Pyramid	Striped Sphere

TABLE III

SAMPLE PROBLEM FOR ORIGINAL LEARNING AND

TRANSFER WITH TEXTURE RELEVANT

Trial Number	Original Learning (Texture Relevant)		Reversal Shift (Group D)		ID Shift (Group E)		ED Shift (Group F)	
	+	-	+	-	+	-	+	-
1	Smooth Pyramid	Striped Sphere	Striped Pyramid	Smooth Sphere	Foam Pyramid	Dotted Sphere	Striped Sphere	Smooth Pyramid
	+	-	+	-	+	-	+	-
2	Smooth Sphere	Striped Sphere	Striped Sphere	Smooth Pyramid	Foam Pyramid	Dotted Sphere	Striped Sphere	Smooth Pyramid
	+	-	+	-	+	-	+	-
3	Smooth Sphere	Striped Pyramid	Striped Pyramid	Smooth Sphere	Foam Sphere	Dotted Pyramid	Smooth Sphere	Striped Pyramid

CHAPTER III

RESULTS

All statistical analyses were carried out using logarithmic transformations of errors to criterion.

Original Learning

The mean number of errors to criterion for those Ss having texture relevant and those having form relevant were analyzed by means of a t test. Mean errors for the form relevant group were 5.5 (mean log errors = .6281) and for the texture relevant group were 17.1 (mean log errors = 1.0011). The difference between groups was significant ($t = 3.008$, $df = 43$, $p < .01$). This indicates that form is the more potent dimension. While 3 Ss failed to reach criterion in the texture group, none failed in the form group.

Figure 1 shows the backward learning curves (Hayes, 1953) for the two groups using per cent correct responses. In the construction of these curves, the scores of the Ss are computed across trials and plotted from criterion day backwards. The curves are continued until the median S meets criterion. A total of 15 Ss reached criterion on the first day in the form relevant group. A total of 9 reached criterion on the first day in the texture relevant group and at the end of the second day, 18 Ss met criterion.

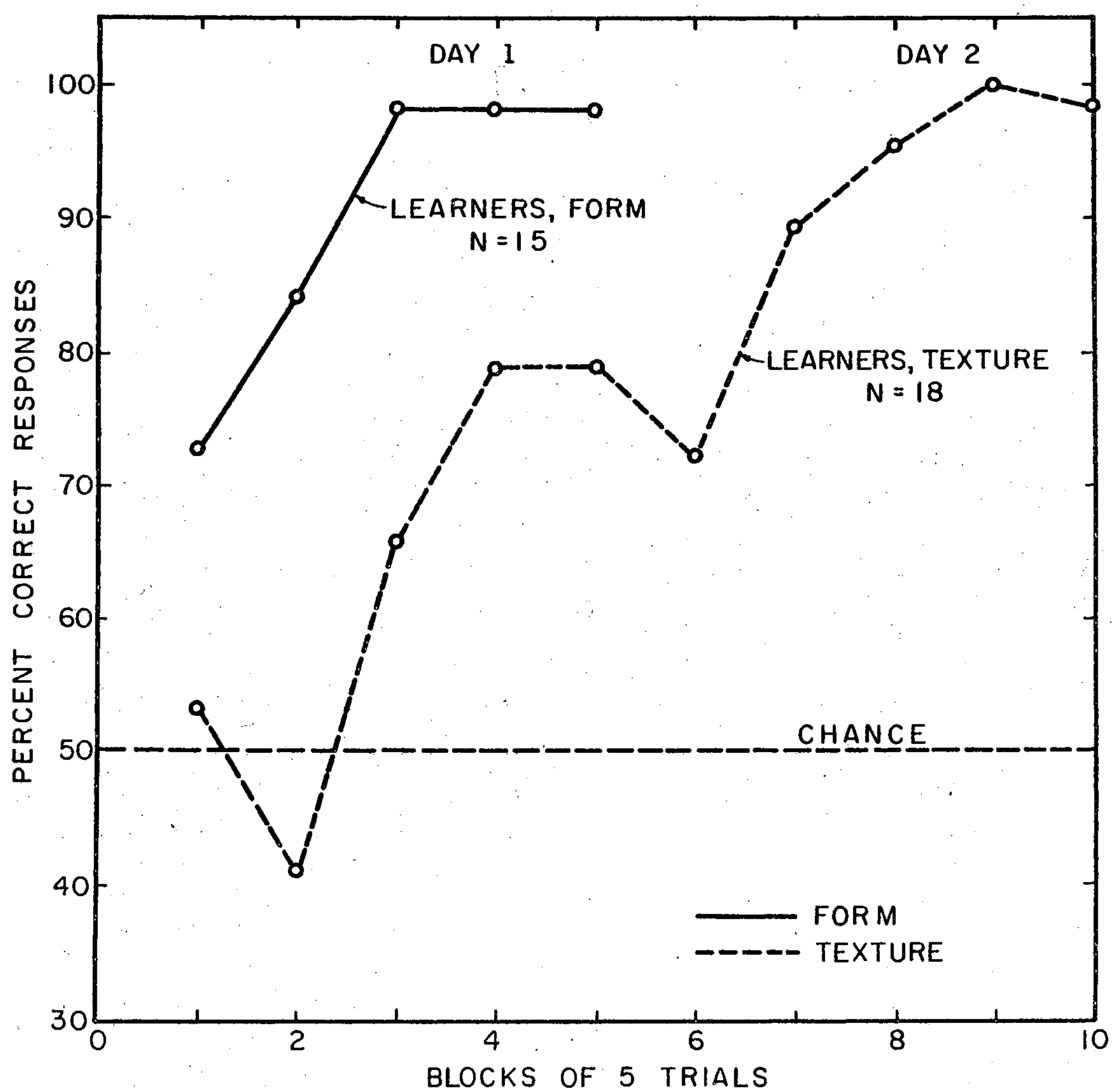

Figure 1. Backward Learning Curves for Groups Having Either Form or Texture Relevant During Original Learning

Transfer Problems

A 2 X 3 factorial analysis of variance was computed using the log errors to criterion for the six transfer groups. The factors were dimension (texture or form) and type of transfer (reversal, ID, or ED). The analysis (Table IV) shows that the main effect due to type of transfer was signigicant ($F = 20.6099$, $df = 2/36$, $p < .005$). Here, the main effect of dimension was not significant. This could possibly be attributed to the fact that the probability of observing the relevant dimension was high for reversal and ID groups and at a similar low level for the two ED groups. There was no significant interaction between dimension and shift.

TABLE IV

2 X 3 FACTORIAL ANALYSIS OF VARIANCE FOR DIMENSION AND SHIFT USING LOG ERRORS TO CRITERION

Source	d.f	MS	F
Dimension (A)	1	.0078	
Shift (B)	2	2.5577	20.6099*
A X B	2	.0049	
Error	36	.1241	

* .005

Since the main effect due to dimension was not significant, the number of errors to criterion for each of the 3 types of transfers was combined across dimensions. Using Duncan's multiple-range test (Table V), the difference between the ED and ID treatment means and the ED

TABLE V

ANALYSIS OF TOTAL NUMBER OF ERRORS TO CRITERION FOR REVERSAL, ID, AND ED SHIFT GROUPS USING DUNCAN'S NEW MULTIPLE-RANGE TEST

Mean Number of Errors to Criterion for Rev, ID, and ED Shift Groups Combined Across Dimensions

Reversal (B_1)	ID (B_2)	ED (B_3)
3.7235	3.8235	8.9551

1% Multiple-Range Test

Value of p	2	3
SSR	3.82	3.99
Rp = LSR	.9511	.9935

$B_3 - B_1 = 5.236 > .9935$; significant

$B_3 - B_2 = 5.1316 > .9511$; significant

$B_2 - B_1 = .1000 < .9511$; not significant

5% Multiple-Range Test

Value of p	2	3
SSR	2.86	3.01
Rp = LSR	.7121	.7494

$B_2 - B_1 = .1000 < .7121$; not significant and reversal treatment means was significant at the .01 level with ED performance being significantly poorer than both ID and reversal performance. The difference between the reversal and ID shift groups was not significant (df = 36, $\alpha > .05$).

Backward learning curves were plotted using per cent correct responses. The results for the transfer groups were collapsed across dimensions. Figure 2 shows graphic evidence of the poorer performance on the ED transfer problem which the AOV substantiates. It took the median S two days to meet criterion for the ED transfer while in both reversal and ID transfer, the median S met criterion on the first day. It can be noted that both the reversal and ID functions are similar toward the end of the criterion day but that the performance level of the reversal group starts at a relatively lower level. The first reversal point is elevated because the performance was averaged over the first five trials. As can be seen in Figure 3, the per cent correct responses for the combined reversal groups was at a lower level (14 per cent) on trial one as predicted by the theory. Figure 3 shows the first ten trials of shift performance. This indicates positive transfer of Po in the ID and reversal shift groups as shown by the negatively accelerated function. That the ED function remains at a chance level is indication of negative transfer.

Figures 4 and 5 show the learning functions of the per cent correct responses for each reversal shift group plotted from day one. Examination of the first ten trials (Figure 5) shows that if the reversal midplateau is present, the period of positive acceleration is extremely short.

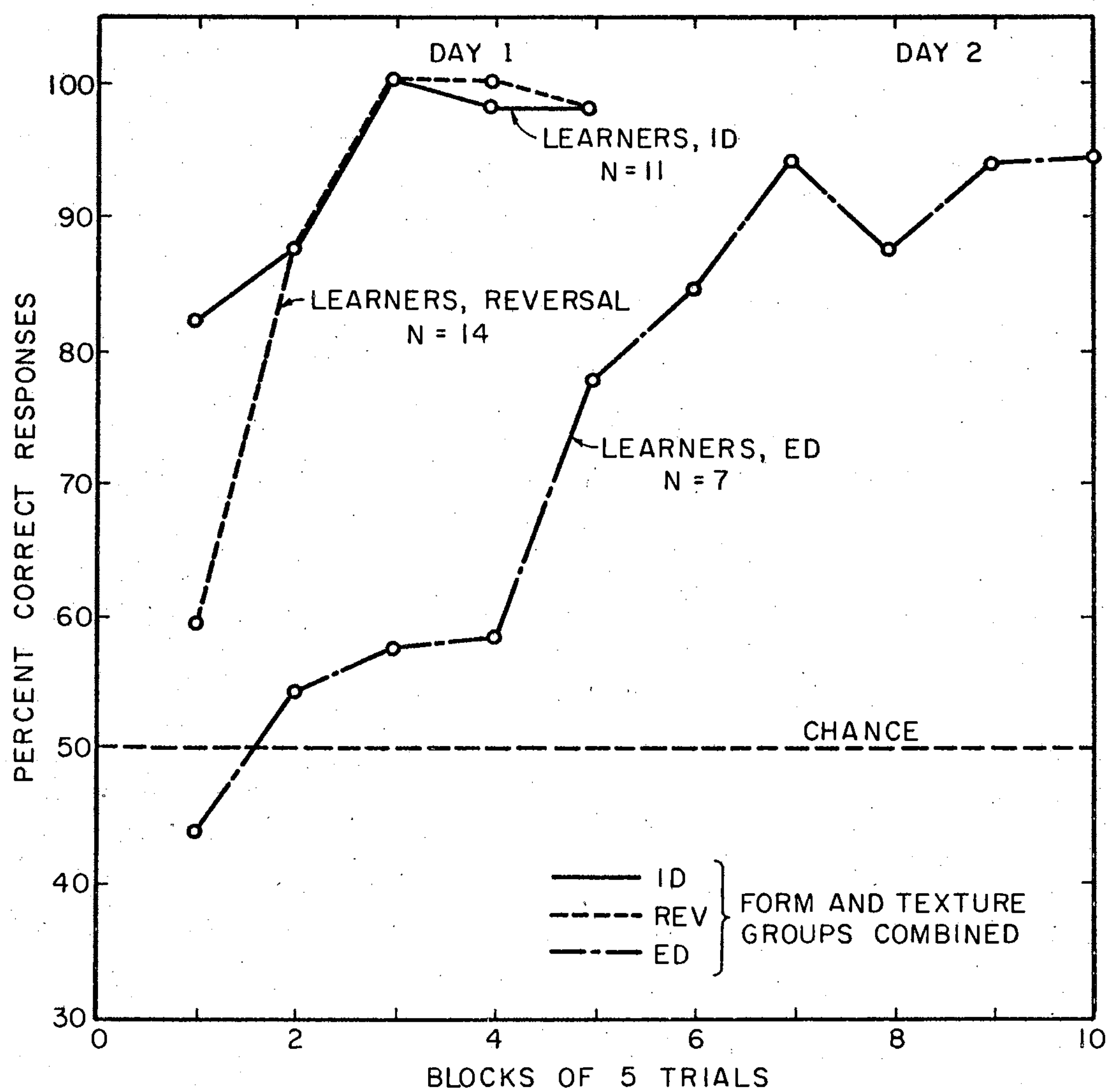

Figure 2. Backward Learning Curves for Reversal, ID, and ED Shift Groups

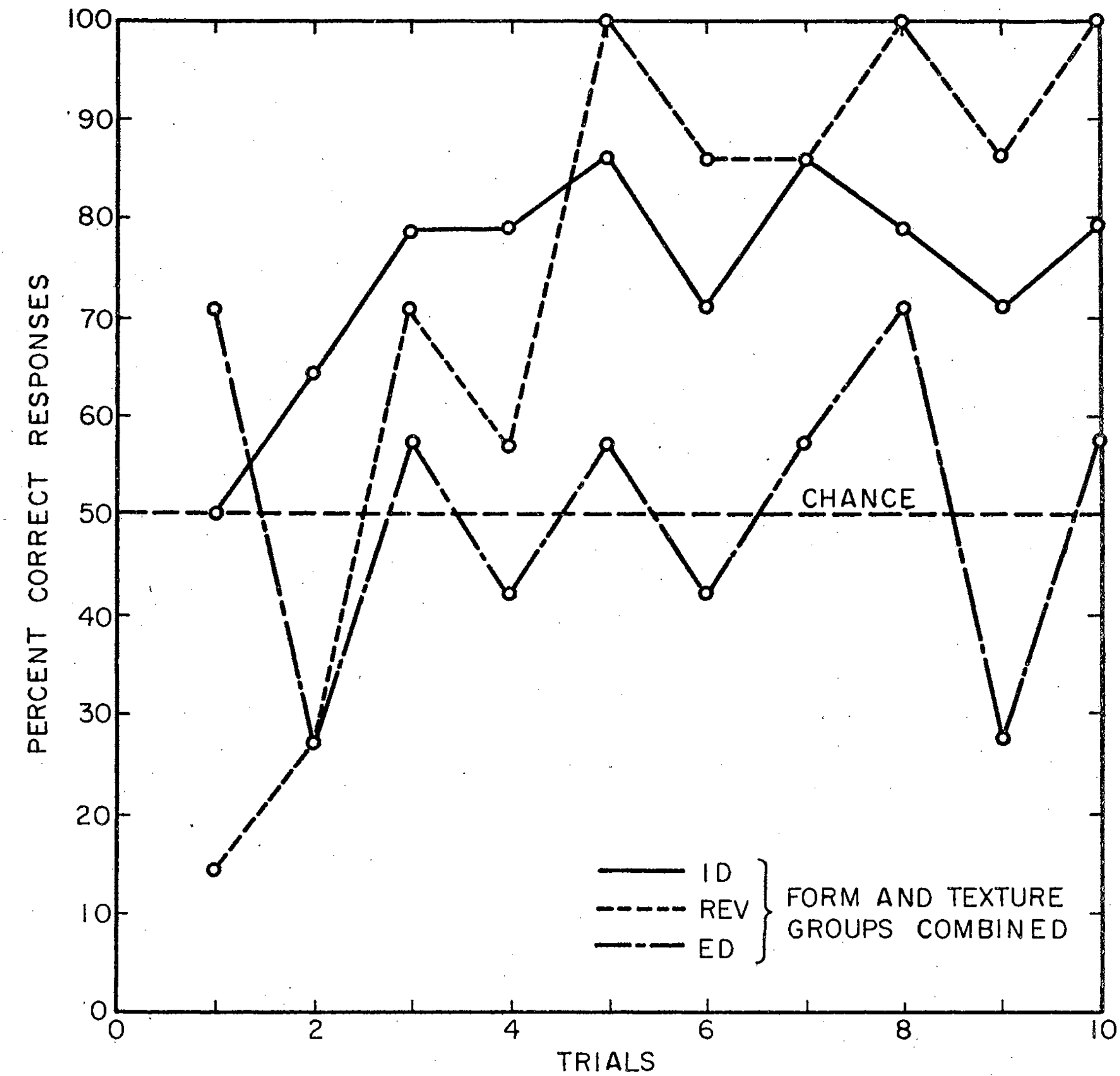

Figure 3. Forward Learning Curves for Reversal, ID, and ED Shifts for the First Ten Trials

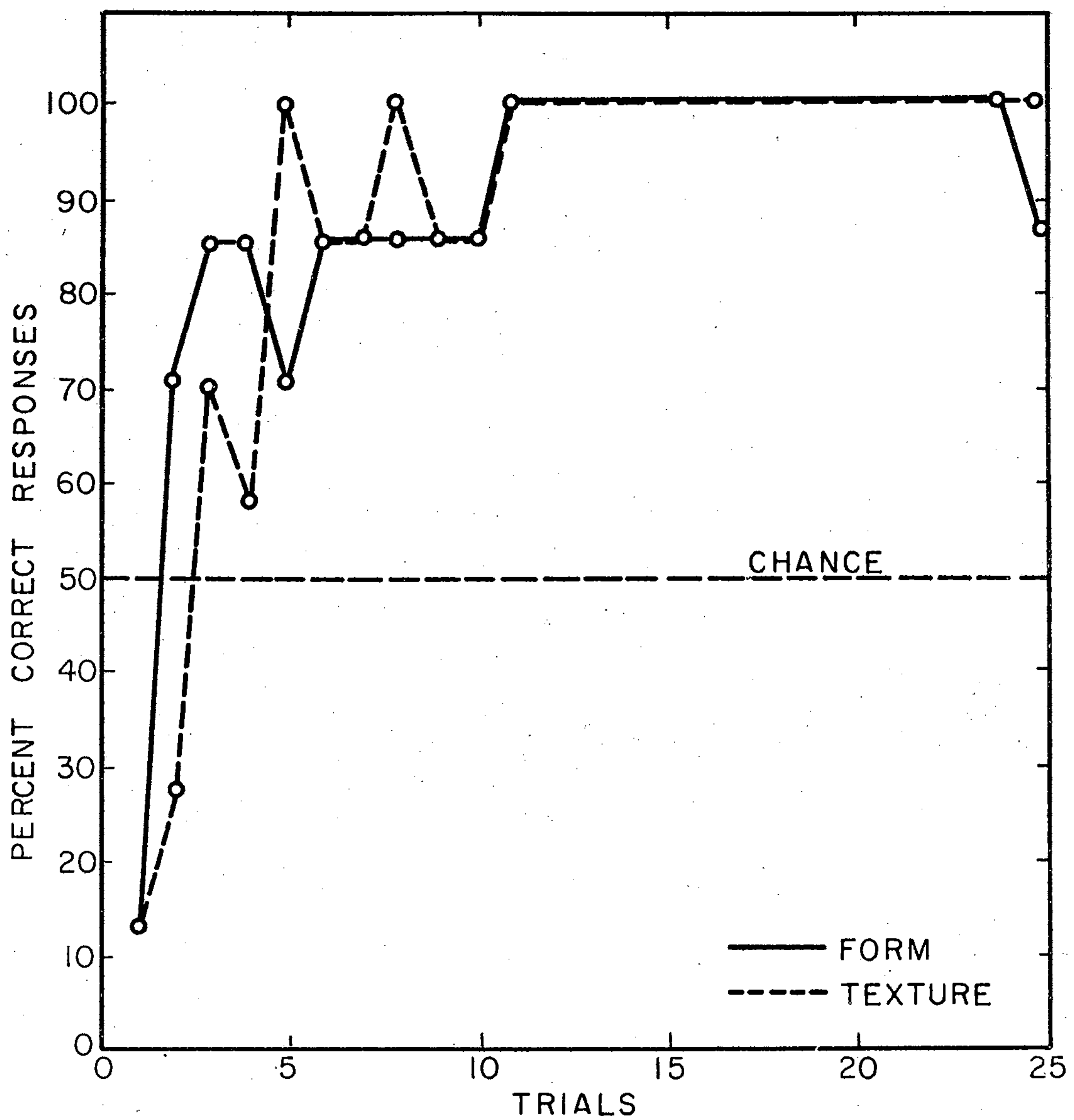

Figure 4. Forward Learning Curves for Reversal Groups

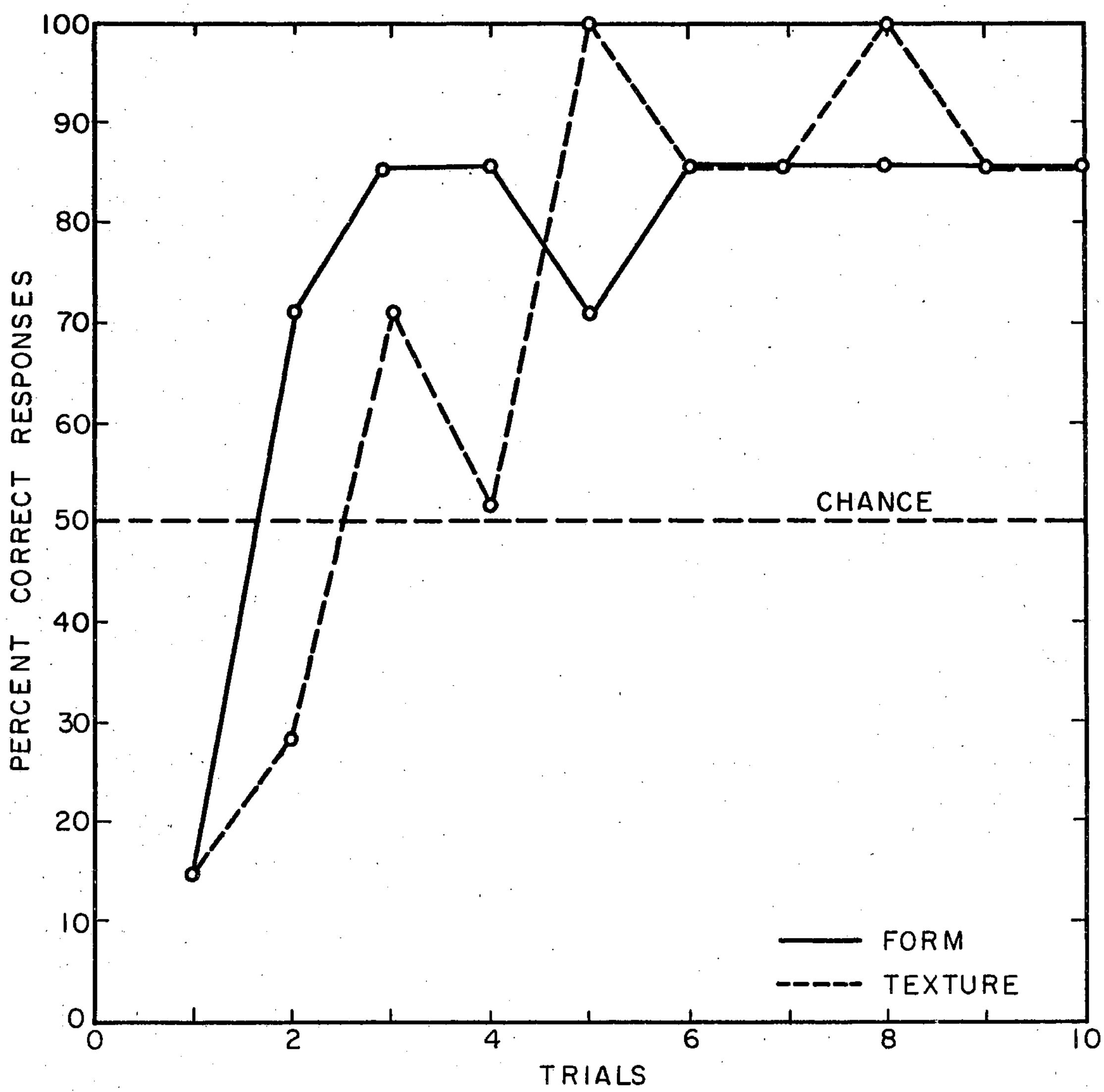

Figure 5. Forward Learning Curves for First Ten Trials of Reversal Groups

CHAPTER IV

DISCUSSION

The acquisition functions for the two main groups (form relevant or texture relevant) are similar to those obtained in visual discrimination. The functions in Figure 1 are ogival in form with a fast rise to criterion. The backward learning curve for the texture relevant group illustrates the initial flat portion before the sharply rising approach to criterion is observed. Similar ogival curves were obtained by Zeaman and House (1963) for visual discrimination problems.

The results of the shift performance are in accordance with the predictions of Attention Theory, thus giving further confirmation to the theory. The ED shift was significantly more difficult than the ID shift or reversal shift. The ID shift is an instance of positive transfer since the previously relevant observing response (Po_1) remains relevant to problem solution in the transfer problem. The ED shift performance is not facilitated by the transfer of a high Po from the previous problem. The new relevant dimension which was irrelevant during original learning has a low Po value at the beginning of the transfer problem. In both ED and ID shifts, the probability of making the correct instrumental response (Pr_1) is at a chance level.

The reversal shift is also facilitated by a positive transfer of Po_1 since the relevant dimension remains the same in the transfer problem. However, the shift Pr value is at a level complimentary to the Pr_1 value at the end of original learning. That the reversal transfer is superior to the ED transfer is indication of the importance of a high tendency to observe the relevant dimension. In the reversal situation, the S has an increased probability of attending to the dimensional cues associated with problem solution.

Further proof of the positive and negative transfer of the observing response is seen in Figure 3 where only the first ten trials of the transfer problems were plotted. From this figure it is evident that solution is facilitated when there is a positive transfer of Po. That performance is above 70 per cent on trial one of the ED problem can be attributed to chance. Although positioning of the cues of the irrelevant dimension is randomly varied, eight of the fourteen Ss had the previously positive cue paired with the new positive cue on trial one of the shift problem. Therefore, the possibility also exists that they were responding to the previously positive cue and not to the cue in the new relevant dimension.

There is no doubt that texture and form are dimensions in the tactual modality as defined by Attention Theory. The fact that there are definite indications of positive and negative transfer in the shift conditions is strong support for the classification of texture and form as dimensions. There is a significant difference in the potency of these two dimensions, form being the more potent, as shown in the analysis of the original learning data. That texture is more difficult can also be verified by the fact that it took the median texture learner 25 more trials to reach criterion than the median form learner. The only Ss who failed to reach criterion for original learning were in the texture relevant group.

The theory makes the prediction that the reversal function should fall somewhere between the ID and ED shift functions. Here, the difference in performance between the reversal and ID shift was not significant. The mean log number of errors to criterion was slightly less for reversal than ID (3.7235 and 3.8235 respectively). Similar results of no difference between ID and reversal shifts were obtained by House and Zeaman (1962). The reversal function, in relation to the ID and ED functions, can fall anywhere depending upon the probability of observing the relevant dimension at the start of reversal, the rate of change of Po and Pr, θ (growth parameter), and the number of dimensions competing for attention (n).

A unique prediction in Attention Theory is the presence of a reversal midplateau. The plateau is affected by several parameters of the system - Po, Pr, n (number of dimensions), and θ(growth parameter). The affects of Po and Pr on the length of the plateau are dependent upon the values of θ. Assuming that the values of θ are equal for acquisition and reversal, low values of Po_1 will accentuate the plateau and high Po_1 values will reduce the plateau.

That the presence of a reversal midplateau is questionable can be seen in Figure 3. However, the criterion used for original learning was stringent resulting in a high value of Po_1 at the end of original learning. The value of Pr reaches near unity much sooner than Po and the more stringent the criterion, the greater possibility of Po_1 being near unity also. It can be assumed that Po_1 was near unity at the start of reversal, thereby resulting in a less apparent period of positive acceleration or the midplateau.

Although no strong evidence for the reversal midplateau was found, the evidence collected offers firm support for the applicability of Attention Theory to tactual-kinesthetic discrimination learning. The shapes of the acquisition functions are similar to those predicted for visual problems and the relative difficulty of ED, ID, and reversal shifts follows the theory and findings reported by Zeaman and House. It would appear, therefore, that Attention Theory need not be restricted to the visual modality but may be considered a more general model of retardate discrimination learning.

CHAPTER VI

SUMMARY AND CONCLUSIONS

This study investigated the tactual-kinesthetic discrimination learning of retarded children within the theoretical framework of Attention Theory. Subjects were given a training problem having either texture or form as relevant dimensions and then transferred to one of three shift conditions.

The results of the study were in accordance with the predictions of Attention Theory. The shapes of the acquisition functions were the same as those obtained by Zeaman and House for visual discrimination. The ED shift performance was inferior to that of the ID and reversal shifts as predicted by the theory. It was firmly established that form and texture are dimensions within the tactual-kinesthetic modality with texture being significantly more difficult than form. The presence of the reversal midplateau was questionable.

It can be concluded that the Attention Theory of Zeaman and House is applicable to other modalities as well as to visual discrimination, and can therefore be considered a more general theory of retardate discrimination learning.

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APPENDIX A

INSTRUCTIONS

Rapport is initially established between S and E and the S is introduced to the "candy game." Instructions given to the S are as follows: "Put your hands into these holes and reach down to see if you can find the candy." (No stimuli are over the foodwells.)

After S withdraws his hands, one junk object is placed over a foodwell and the following instructions given: "This time when you put your hands in, you will feel something; push it back and find the candy and then pull your hands out."

The same procedure is followed again, but the stimulus object is placed over the opposite foodwell. On the fourth trial a junk object is placed over each foodwell, one of them being the junk object previously used. The S is instructed: "This time you will feel something in each hand and to play the game right, you must only push one back at a time to find the candy. What you touch tells you where the candy is. After you push one back, pull your hands out and wait until you are told to put your hands in again to find the candy."

If S makes the incorrect response, E says, "Remember, what you touch tells you where the candy is."

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