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Attention in Discrimination Learning of Young Children[1]

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This study investigated the separate effects of attention to the relevant dimension and instrumental responses to dimensional values on the learning rates of discrimination shifts by four-year-old children. The separate effects were assessed by comparing pairs of shifts: intradimensional and extradimensional; reversal and intradimensional, respectively. Two experiments which varied the nature of the stimuli were performed: in the first, patterns served as stimuli and the reversal was slower than either of the other shifts which were learned about equally fast. In the second, objects served as stimuli and the intradimensional shift was faster than either of the others which were learned at about the same rate.

These findings indicate that transfer of an observing or attentional response to the relevant dimension occurred for objects but not for patterns. Although such attention transferred, it was not sufficient to overcome the effects of original instrumental learning on the reversal problem. The findings were discussed with reference to two-stage theories of discrimination learning which treat attention and prior instrumental learning as separate factors and mediational theory which tends to identify responding to the relevant dimension as mediation.

This paper is concerned with a theoretical problem posed by the findings comparing discrimination reversal with other kinds of shifts. In general, infrahuman animals and young children (without overtraining) have difficulty learning the reversal shift, whereas older children and adults learn the reversal faster (Kendler and Kendler, 1962). As single-unit, stimulus-response theories have proven inadequate in han-

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dling such results, current formulations have added assumptions which involve either attention (Zeaman and House, 1963; Sutherland, 1964) or the development of "mediation" (Kendler and Kendler, 1962). These positions have been characterized as two-stage models of discrimination learning (cf., Mackintosh, 1965). During the initial discrimination, one stage of learning involves the establishment of observing or attentional responses to the relevant dimension; the second stage involves the learning of instrumental responses to the values of the relevant dimension.

All models apparently assume that *S* learns to respond to the dimensionality of the relevant stimuli but they differ in explanation as to how a reversal may be facilitated. For Zeaman and House (1963), the rate of reversal learning depends upon both the degree of transfer of the observing response and the rate of learning the new instrumental response assignments. If the initial probability of the observing response is high, the reversal learning should be facilitated. However, as they indicate (p. 194), without a knowledge of the parameter values for observing responses and instrumental response extinction-acquisition, predictions from the theory are indeterminate. Sutherland (1964) also emphasizes attention. In his model, the case of reversal learning depends upon the relative strength of both the attentional response and of prior instrumental responses. When training is to a weak criterion, the attentional response is assumed to extinguish more rapidly than the previous instrumental habit, resulting in slower reversal learning. If overtraining is given, the attentional response extinguishes more slowly than the instrumental habit and reversal is facilitated. In comparison, the Kendlers (1962) are less explicit in identifying the respective roles of the two stages during transfer (cf., Mackintosh, 1965). According to Kendler and Kendler, if an *S* is a "mediator," he learns a reversal shift more readily than a nonreversal shift. The mediation process is assumed to be a response to a stimulus dimension, such as color, but it is unclear as to how such a mediating response facilitates the reversal of the overt instrumental responses to stimulus values of that dimension. It appears that they implicitly assume either that the mediation response of attending to the relevant dimension extinguishes more slowly than the instrumental responses or that mediation also involves rapid instrumental extinction. Either of these assumptions would predict faster reversal learning, given mediation. In any event, all positions suggest that attention or responding to the relevant dimension and its transfer are critical for faster reversal learning.

The present study was conducted to assess whether attention or responding to the dimensionality of the relevant stimuli, *per se*, is sufficient to facilitate reversal learning of young (four-year-old) children.

Although both attention and instrumental responding are viewed as occurring in a time-dependent, two-stage chain (e.g., Kendler, Glucksberg, and Keston, 1961), it is possible that species and/or developmental differences exist where one process may operate more strongly or perhaps independently of the other. For example, Kendler (Exp. I, 1964) provided young children with verbal labels (e.g., "Black wins, White loses") which facilitated the initial discrimination and presumably increased the probability of initially observing the color dimension. However, in the second phase, reversal learning was not facilitated when compared to controls who were not provided labels. Yet, in the third phase, optional tests indicated that mediation (responding to the total color dimension) did occur more often for those who had labelling experience than those who did not. Since the verbal *Ss* persisted in responding to the previously correct stimulus during phase two, prior instrumental responses failed to extinguish as rapidly as might be anticipated from a mediation viewpoint.

In order to assess the relative roles of the attentional and instrumental habits, the present experiment used single-dimensional rather than conventional two-dimensional problems (cf., Kendler and Kendler, 1962). To illustrate, consider three kinds of shifts: reversal, intradimensional, extra-dimensional. Suppose all *Ss* learn the same final problem where color is relevant; a red stimulus is reinforced and a blue one is not. A reversal *S* learns an initial problem with the same stimuli but the blue value is reinforced and the red is not; an intradimensional *S* learns an initial problem involving different color values; an extradimensional *S* learns an initial discrimination with a different dimension (e.g., size) relevant and no color present (i.e., both objects are gray). Now, consider which process operates in each problem. For an extradimensional shift, neither attention to the previously relevant dimension nor prior instrumental response learning operates since the stimuli are from a different dimension and past associations are therefore removed. In an intradimensional shift, the attentional response may transfer since the new stimuli are from *within* the previously relevant dimension while prior stimulus-response associations are absent. For a reversal, however, both processes may operate since the same relevant stimuli and prior associations are present.

How may the relative strengths of the two habits be assessed and what outcomes may be expected for the three shift conditions? Inferences regarding the relative strengths of the two habits involve comparisons between two pairs of problems: for strength of prior stimulus-response associations, the reversal is compared with the intradimensional shift; for attention, the intradimensional is compared with the extradimensional shift. If prior stimulus-response associations are resistant to extinction, the reversal problem would be slower than the intradimensional one, regardless of the transfer of attention. If responding to the relevant dimension is learned and transfers, the intradimensional shift should be learned more rapidly than the extradimensional problem. Finally, according to each view, if either (a) attention transfers and the rate of new instrumental learning is fast or (b) the attentional habit is stronger than prior instrumental learning or (c) mediation occurs and overcomes prior associations, the reversal shift should be learned faster than the extradimensional one.

In addition to allowing assessment of the above processes, the use of single-dimensional problems appeared to have certain advantages over the conventional, two-dimensional task. Methodological and theoretical considerations that result from partial reinforcement both during initial training and shift learning are circumvented by the absence of the irrelevant dimension. The initial probability of an error, for all shifts, may be experimentally set at unity. Finally, in comparisons of different nonreversal shifts, stimulus change or novelty is common and therefore controlled.

PILOT STUDY

In order to make results from single dimensional shifts relevant to previous studies, the first of the three experiments was a pilot study comparing learning rates on reversals for young and older children.

METHOD

Subjects. The *Ss* were fifty-three nursery school children from the West Los Angeles area. Their ages ranged from 2½–9½ years (median = 4½ years). Twenty-seven *Ss* failed to reach the learning criterion for the initial discrimination and did not undergo a reversal shift; of the twenty-six who learned and underwent reversal training, 12 were under and 14 were over 6 years (medians = 4 years and 3 months and 8 years and 1 month, respectively).

Stimuli and apparatus. The stimulus materials were red or blue rectangular cutouts (2×2 inches) centered on a white paper plate (8-inch diameter). The apparatus consisted of a table, two paper plates, and a hand-movable screen (20×24 inches). The reinforcements were plastic trinkets.

Procedure. Each *S* was run individually. The *S* was seated at a table across from *E*. To begin, *E* placed the two plates before the *S* and read the following instructions:

> You are going to play a game called 'Find the Prize.' I will hide the prize under one of these two plates. You have to find the prize. On each turn, you may look under one of these two plates. You cannot look under both plates on a turn. If you do not find a prize under the plate that you pick, you will have to wait until your next turn to look again. Remember, you have to try to find the prize each time I let you pick a plate. You may keep the prizes you find, so, each time you find one, put it in this envelope.

After reading the instructions, *E* placed the screen between the child and plates. The position of the plates was switched and the screen removed. In order to control for stimulus preferences, *S*'s first response was unrewarded, regardless of choice. The positive value (red or blue) was then defined as that plate the child did not choose. Training on the initial discrimination began on Trial 2: *E* replaced the screen, put a trinket under the appropriate plate, and presented the plates to the child for his choice. All subsequent trials proceeded in this fashion until learning criterion or 100 trials occurred.

In Trials 1–10, the position of the correct plate was determined by a Gellermann sequence. On subsequent trials, the positions were randomized with the restriction that the correct plate occurred in both positions about equally often and not more than three successive trials in the same position.

The learning criterion for the initial problem was eight successive correct choices. If *S* learned, the problem was reversed by then reinforcing that stimulus which was not rewarded in the initial discrimination. Subjects who failed to reach criterion within 100 trials were not reversed. On reversal, the learning criterion was the same as initial training: eight successive correct choices within 100 trials.

For each problem, the data were the number of errors made in either reaching criterion or 100 trials.

RESULTS

For all fifty-three *Ss* in initial training, age was uncorrelated with errors ($r = .041$, $p > .05$). These *Ss* were divided into two age groups of those under or over 6 years. The mean number of errors per group was 23.29 and 22.52, respectively; the difference was not statistically reliable ($t = .04$, $df = 51$, $p > .05$).

For the twenty-six *Ss* who underwent reversal training, age and errors were negatively correlated on the reversal problem ($r = -.46$, $p < .05$). The younger group learned the initial discrimination problem faster than the older group (mean errors were 3.73 and 12.73, respectively; ($t = 3.58$, $df = 24$, $p < .05$). Since only color was revelant, this finding suggests that a preference for color by the younger children may have operated. Color preferences are stronger for children under six (Suchman and Trabasso, 1966a) and have been shown to lead to faster discrimination when the preferred dimension is relevant (Suchman and Trabasso, 1966b). Despite this confounding of age and ability, the older *Ss* reversed faster than the younger one (mean errors were 7.40 and 31.54, respectively, $t = 3.11$, $df = 24$, $p < .05$), a result in line with previous findings on two-dimensional problems. If color preferences operated as observing responses to color, the fact that reversal was still slower for the young children suggests that attention to the relevant dimension was not as strong as prior instrumental habits during reversal learning.

EXPERIMENT I

In Exp. I, the three kinds of shifts are compared with single-dimensional problems. In addition, a fourth group was included in which *Ss* were told at the outset of the reversal problem that the problem was a new one.

Method

Procedure, apparatus, and stimuli. The procedure, apparatus, and instructions of Exp. I were identical to those used in the pilot study. The stimuli were unidimensional and consisted of a pair of values from one of two stimulus dimensions: color or shape. The respective pairs were: red vs. blue, yellow vs. green, circle vs. triangle, and hat vs. cross.

Experimental conditions. Each *S* was randomly assigned to one of four shift conditions. The stimulus-reinforcement assignments in the initial and shift problems defined the nature of the shift. Four shifts were studied: Reversal, Instructed Reversal, Intradimensional, and Extradimensional. Position was the only irrelevant dimension present in all problems.

For Reversal, identical stimuli appeared in both problems; whichever value was initially reinforced became incorrect during the shift.

For Instructed Reversal, the situation was identical to that of the Reversal condition except that between the two problems, the *Ss* were told: "We have now finished one game. That was very good. Now we are going to start a new game."

For Intradimensional, different pairs of the stimulus values from the same dimension were used in each problem.

For Extradimensional, different pairs of stimulus values from different stimulus dimensions were used in each problem.

For the first three conditions, *Ss* were irregularly assigned to one of four possible problem orders which counterbalanced stimulus-response

assignments and value pairs. In the Extradimensional condition, there were eight such orders since two different stimulus dimensions were used.

The learning criterion was eight successive correct choices within 64 trials on the initial discrimination. The latter number was used since in the pilot study, no *S* who solved required more than 64 trials. Subjects were shifted to the second problem if learning criterion was reached in the initial discrimination. With the exception of the Instructed Reversal *Ss*, no interruption in procedure occurred between problems.

Data. The data consisted of the number of errors and trial of last error for each problem. For *Ss* who did not solve, the trial of last error was 64. As means and variances of these measures were correlated, the data were subjected to a square-root transformation. Statistical tests yielded similar findings on both measures and only the square-root of errors data are reported.

Subjects. The *Ss* were sixty-nine nursery school children in the West Los Angeles area. Their ages ranged from 3 to 5½ years (median = 4 years and 4 months). Twelve *Ss* failed to learn the initial discrimination task and were not shifted; these *Ss* were replaced with ones who learned the initial task. Because of randomization and replacement procedures, the final distribution of *Ss* for shift comparisons were 15 Reversal, 9 Instructed Reversal, 13 Intradimensional and 20 Extradimensional.

Results

For initial learning, an analysis of variance on the transformed error scores yielded nonsignificant *F*-ratios for the four conditions, two stimulus dimensions and their interaction. Table 1 gives the mean scores for each of the four conditions of Exp. I.

TABLE 1
MEAN ERRORS IN INITIAL TRAINING (Exp. I)

Shift condition	Mean transformed errors
Reversal	2.01
Instructed reversal	3.04
Intradimensional	2.72
Extradimensional	3.52

Table 2 gives the mean transformed scores and standard deviations for each shift problem.

In Table 2, the individual comparisons between means were made by *t*-tests, with the .05 level of significance. The Reversal group learned

TABLE 2
MEAN ERRORS IN SHIFT LEARNING (Exp. I)

Shift condition	N	Mean transformed errors	SD
Reversal	15	4.14	1.59
Instructed reversal	9	2.70	1.86
Intradimensional	13	1.89	1.42
Extradimensional	20	2.76	1.93

more slowly than either the Reversal Instructed ($t = 2.05$, $df = 22$), the Intradimensional ($t = 3.88$, $df = 26$) or the Extradimensional ($t = 2.23$, $df = 35$) groups, respectively. The difference between means for the Intradimensional and Extradimensional groups was not significant ($t = 1.38$, $df = 31$). These results indicate that no significant transfer of an observing response occurred, but that prior instrumental habits retarded reversal learning. The exception to the latter conclusion occurred in the Instructed Reversal group, where the instructions concerning a new problem effectively reduced the error rate.

EXPERIMENT II

Since the results of Exp. I indicated that children in this task did not transfer an appropriate observing response, the question of dependency between the extinction and attention-transfer processes is not clearly answered. For, if overcoming prior stimulus-response associations depends upon observing (i.e., the *Ss* must somehow receive the stimulation in order to discriminate), then the failure to transfer an observing response would also lead to a failure to extinguish instrumental tendencies rapidly. Observing responses are more likely to occur in those situations where the stimuli are salient, such as where the discriminanda are objects rather than patterns (House and Zeaman, 1960). To maximize the possibility of obtaining transfer of an observing response, Exp. II essentially replicated Exp. I with objects rather than patterns.

Method

Subjects. The *Ss* were thirty-seven nursery school children from the West Los Angeles area. Their ages ranged from 3 to 5 years (median = 4 years). One *S* failed to learn the initial discrimination; all remaining *Ss* learned and were haphazardly assigned to one of three experimental conditions. There were 12 *Ss* in each condition.

Stimuli. The stimuli were two wooden blocks and the values were from two dimensions, color or size. The colors were the same as in Exp. I. When color was relevant, the blocks were the same size (2 cubic inches). When size was relevant, the blocks were medium gray and were large (2½ cubic inches) and small (1 cubic inch).

Apparatus. From *S*'s viewpoint the display consisted of two wooden blocks (3 inches apart) placed on a semicircular platform in front of a rectangular barrier. The display apparatus was actually a circular platform (15-inch diameter) which was perpendicularly bisected by a rectangle ($8 \times 15 \times \frac{1}{2}$ inches). The barrier and the circle were mounted on a rotating base so that while *S* made choices between the displayed blocks, *E* prepared the display for the next trial. To the *S*'s right was a second barrier, 18×18 inches, behind which *E* stored rewards, stimulus materials and data sheets.

Experimental conditions. There were three shift conditions: Reversal, Intradimensional, and Extradimensional. The differences in the stimulus and reward assignments during initial training compared with those on the final problem defined the nature of the shift. All *Ss* were shifted to the same final color problem (red vs. blue) after learning to discriminate either red vs. blue (Reversal), yellow vs. green (Intradimensional) or large vs. small (Extradimensional) problems. The rewarded values were defined by the same procedure used in the other experiments. Block position was irrelevant and determined by the same randomization procedure as in the other experiments.

Procedure. Except for minor changes in wording regarding stimuli, the instructions, procedure, rewards and criterion of learning were identical to those of Exp. I. The data were transformed error scores.

Results

For the initial discrimination, the groups did not differ significantly in the number of errors before learning ($F = 1.38$; $df = 2,33$; $p < .05$). Table 3 gives the mean transformed error scores for each condition.

TABLE 3
MEAN ERRORS IN INITIAL TRAINING (Exp. II)

Shift condition	Mean transformed errors
Reversal	2.63
Intradimensional	2.43
Extradimensional	1.70

Table 4 summarizes the shift results for Exp. II and presents the mean transformed scores and standard deviations for each shift condition.

Individual comparisons on the shift learning showed that the Intra-

TABLE 4
MEAN ERRORS IN SHIFT LEARNING (Exp. II)

Shift condition	Mean transformed errors	*SD*
Reversal	2.20	.53
Intradimensional	1.48	.57
Extradimensional	2.53	1.65

dimensional shift was learned faster than either the Reversal ($t = 6.30$, $df = 22$, $p < .05$) or the Extradimensional ($t = 4.11$, $df = 22$, $p < .05$) problems. The Reversal group did not differ significantly from that of the Extradimensional group ($t = 1.33$, $df = 22$, $p > .05$). These results indicate that an observing response was transferred but prior instrumental habits failed to extinguish rapidly.

DISCUSSION

While it is recognized that other stimulus factors may have been responsible for the differences obtained between the two experiments, a reasonable conclusion is that when the discrimination is made easy by the use of objects instead of patterns, young children are more likely to learn an intradimensional shift faster than a problem involving a new dimension. This means that attention to the relevant dimension can be learned and transferred by four-year-old children. However, despite this attentional learning with objects, the children still do not learn a reversal shift faster under the same conditions. Thus, transfer of attentional responses *per se* is an unlikely explanation of the facilitation of reversal learning when this occurs. The role of prior instrumental habits would have to be considered by any theoretical explanation of shift results.

These findings raise questions regarding the Kendlers' (1962) definition and theoretical use of mediation. As indicated, mediation is defined in terms of the *S*'s tendency to respond to the overall dimension and his subsequent efficient reversal performance. The present results show that four-year-old children may respond to the overall dimension but still not perform like "mediators" and reverse faster. Therefore, an alternative interpretation of the observed "mediation deficiency" appears necessary. Some insight is provided by considering the instructional result of Exp. I. There it was shown that difficulty in reversal was substantially reduced by informing the child at the end of original training that the game was finished and a new one was to begin. This instruction facilitated reversal (mediation) but of a different order than dimensionalization. The additional mediation process which occurs in efficient reversal

learning may be the operation of a response rule to shift in the face of nonreinforcement for the previously correct response. Such a rule may entail what Harlow (1959) terms a "win-stay, lose-shift" strategy derived from considerable, nonspecific problem-solving experience. In the two-choice discrimination reversal problem, this strategy would facilitate learning since all the *S* has to do, given he is attending, is to avoid the previously correct stimulus. The success of instruction in Exp. I implies that the instruction was a strong cue for this type of mediational response, and when nonreinforcement of the prior instrumentally correct response occurred, rapid extinction resulted.

The fact that responding to the relevant dimension need not be coupled with improved performance on reversal does not pose such theoretical difficulties for the theories of Zeaman and House (1963) and Sutherland (1964), discussed above. These systems allow dimensional responding with persistence of prior instrumental habits. The problem for these positions is to indicate under what conditions the instrumental responses might be expected to extinguish rapidly.

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