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ABSTRACT

Errorless discrimination training is a technique in which the discriminative stimulus is supplemented with a salient cue which is gradually removed or faded during the course of training. In this study errorless discrimination training was used to teach preschool children the distinctive features of letters of the alphabet that are difficult to discriminate. To test the hypothesis that the success of EDT depends on whether or not stimulus control is transferred from the obvious cue used during training to the relevant dimension of the discriminative stimulus, two EDT groups were used. For group EDT-1, the obvious cue was superimposed over the feature of the letter differentiating it from its paired comparison. For group EDT-II, the obvious cue did not specifically enhance the distinctiveness of the relevant dimension. A third group, R-E, was taught by the traditional reinforcement-extinction approach. Ss were 108 four- and five-year-olds in pre-kindergarten classes. Six letter combinations, R-P, Y-V, G-C, Q-O, M-N, and K-X, were used in a match-to-sample format, with 10 training trials for each letter combination. Five posttest trials and five delayed posttest trials one week after training were given. The EDT-I group made fewer errors on the two posttests than either of the other groups. The EDT-I group also made significantly fewer errors during training than the R-E group. (KM)

Teaching Children to Discriminate Letters of the Alphabet through Errorless Discrimination Training[1]

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A common procedure used in classroom and laboratory discrimination learning situations involves telling the child whether or not his choice of the stimulus to be discriminated is correct. For example, in the initial stages of learning to discriminate among alphabet letters, a child is presented the letter to be discriminated on a number of trials and is given feedback by the teacher as to whether or not his response was correct. The child is given positive feedback if his response is correct, but he is often uncertain as to why the discrimination is correct. It is possible that the child could make the correct response without being aware of the salient cue that differentiates one letter from another. If the child makes an incorrect response, he is given negative feedback and presented with the same letter on another occasion. Unfortunately, he is seldom taught the distinctive feature of the letter that must be recognized in order to make the correct discrimination. Incorrect responses indicate that the child has responded to a cue that provides irrelevant information for making the correct discrimination. Thus allowing the child to respond to an irrelevant cue and then attempting to extinguish that incorrect response would appear to be an ineffective way of teaching children to discriminate letters.

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This procedure of reinforcement and extinction inevitably entails errors, and according to Moore and Goldiamond (1964), Sidman and Stoddard (1967), and Powers, Cheney, and Agostino (1970), it is not the most efficient means of visual discrimination training. These studies have shown that by using an errorless discrimination training (EDT) technique, children learned a match-to-sample visual discrimination task much more efficiently and quickly than by the conventional reinforcement-extinction approach which trains on the final discrimination alone. The procedures involved in EDT are based on Terrace's work (1963) which demonstrated that pigeons could learn a red-green discrimination without errors if the correct and incorrect stimuli differed initially with respect to brightness and length of time presented. As the pigeons responded to the correct stimulus, the difference between the correct and incorrect stimulus was narrowed. When the EDT procedure is applied to humans the discriminative stimulus is supplemented with a salient cue which is gradually removed or faded during the course of training.

Not all studies using EDT have been successful in transferring stimulus control from the salient cue provided during training to the final stimulus to be discriminated. In such cases, the child makes few errors during training but does not make the correct discrimination on the criterion or transfer tasks. Bijou (1968) taught normal and retarded children mirror-image discriminations with EDT but had difficulty getting the children to transfer stimulus control from the faded obvious cue to the stimulus on which the final discrimination was made. Gollin and Savoy (1968) found that children given errorless training made few errors during training and on a reversal discrimination task, while children trained by the traditional reinforcement-extinction procedure made significantly fewer errors on a final transfer task. It is possible that one of the reasons why efficient transfer did not occur is that the fading was done on a cue that was irrelevant to the distinctive features of the discriminative stimulus. During training the child attended to the obvious faded cue but did not attend to other properties of the stimulus that must be comprehended in order to make the final discrimination. If EDT confines the child's attentional response to a specific attribute of the stimulus, then the child may be at a disadvantage when the transfer task is introduced.

In the present study errorless discrimination training was used to teach preschool children the distinctive features of difficult-to-discriminate letters of the alphabet. In order to test the hypothesis that the success of EDT depends on whether or not stimulus control is transferred from the obvious cue used during training to the relevant dimension of the discriminative stimulus, two EDT groups were used. For one group (EDT-I) the obvious cue was superimposed over the feature of the letter differentiating it from its paired comparison. The EDT-I group was compared to a second group (EDT-II) for which the obvious cue used during training did not specifically enhance the distinctiveness of the relevant dimension. A third group (R-E) was taught to discriminate between the letters using the traditional reinforcement-extinction approach.

Method

Selection of Subjects

One hundred and eight children ranging in age from four years, three months to five years, three months were randomly selected from the prekindergarten programs of the Syracuse Public School System. No formal reading readiness skills were taught in the program and a child able to identify any letters of the alphabet was excluded from the sample. Each child was randomly assigned to one of the three treatment conditions.

Training Materials

The discrimination problem for all three groups was presented in a match-to-sample format requiring the child to discriminate between two letters by selecting the letters that matched the sample. Six letter combinations were used: R-P, Y-V, G-C, Q-O, M-N, and K-X. The criterion for selecting these six combinations was based on the work of Gibson (1969) who found that each of these combinations contains letters with a number of similar distinctive features which makes them difficult to discriminate.

The letters were displayed in 80-point tempo bold print and presented horizontally on a 3 1/2 by 9-inch card. The sample was presented at the top of the card with six letters below it, three of which were the same as the sample. The positions of the three correct and three incorrect letters were randomly assigned for each trial, assuring freedom from any order effect.

Errorless Discrimination Training

There were 10 training trials for each letter combination. On the first trial the relevant or irrelevant cue, depending on the treatment group, was highlighted in bright red. On subsequent trials the highlighted cue was gradually faded. On the tenth trial the highlighted cue was black, the same color as the rest of the letter. To achieve this fading effect, a two-color screen tint printing process was used. On the first printing, black was screen tinted from solid black, to 90% black, to 80% black, etc., until none of the black came through the printing. Printed over this was the color red, which was also screen tinted from solid red to 0% red coming through the printing. By this process of screen tinting ten shades of red-black combinations emerged ranging from solid red to black.

Strips of the faded material were placed over the distinctive feature of the letter for the EDT-I group. For example, the stem of the R in the R-P discrimination was highlighted in red and gradually faded during the course of training. The distinctive feature of the letter was not highlighted for the EDT-II group; rather strips of the faded material were placed under the letter.

Procedure

Each child was trained to discriminate three different letter combinations presented in counter-balanced order. For all three groups there were three warm-up trials, 10 actual training trials, five posttest trials and five delayed posttest trials given one week after training. The three warm-up trials consisted of a match-to-sample task using geometric designs. On the first practice trial an experimenter demonstrated the procedure, and on the following two trials the child was asked to match the correct design to the standard. During the training trials the subjects in the two errorless training conditions were not given any feedback after each trial, whereas the subjects in the R-E group were told after each training trial whether or not their responses were correct.

Experimental Design

Fifty-four children were randomly assigned to one of the three treatment groups and taught to discriminate three pairs of letters. A second group or block of 54 children was assigned in the same way to one of the three treatment groups and taught to discriminate between three pairs of letters different from those in block I. The six pairs of letters were divided into two sets or blocks with 54 children in each block; the two blocks amount to a replication of the original study using different pairs of letters. The analysis of the number of errors for each pair of letters within each block was treated as a repeated measures analysis of variance. The overall design was a partially hierarchical three factor design with two between factors, which were treatment and blocks, and one nested within factor, which consisted of sequence nested within blocks. The three letter combinations were presented in six different training sequences with each letter combination presented in one of the three possible orders, one-third of the time. The experimental design is outlined in Table 1. Tukey's Honestly Significant Difference test was used to look at differences between means for the three treatment groups.

Insert Table 1 about here

Results

Separate analyses were done on the number of errors made during the ten training trials, five immediate and five delayed posttest trials. The mean number of errors made during training by block, training group, and order in which the letter combinations were presented are reported in Table 2.

Insert Table 2 about here

The analysis of the mean number of errors made during training revealed a significant main effect for treatment ($F = 14.59$, $df = 2/72$, $p < .01$). None of the other main effects or interactions were significant. Combining the six letter combination across the two blocks, the mean number of errors for the EDT-I group was 4.4; EDT-II, 11.9; and R-E, 16.7. Tukey's test indicated that the number of errors for the EDT-I group was significantly less than the errors made by the R-E group. ($p < .05$). There was no difference between EDT-II and the other two groups. According to these results, the number of errors made by children given errorless discrimination training depended on whether or not a relevant or irrelevant dimension of the discriminative stimulus was highlighted. The children in the errorless training group which highlighted the relevant cue made fewer errors than the children in the R-E group. It was anticipated that both errorless training groups would make relatively few errors during training as compared to the R-E group; however, only the EDT-I group made significantly fewer errors than the R-E group.

The mean number of errors on the posttest given immediately after training are presented in Table 3. The only significant main effect occured between treatments ($F = 12.07$, $df = 2/72$, $p < .01$) and none of the interactions were significant. These results indicate that the effects of treatments were consistent across blocks, order of presentation, and sequence. The mean error score for the EDT-I group was 2.8 which is significantly less than the mean of 7.7 for EDT-II ($p < .05$) and 7.1 for the R-E group ($p < .05$). The slight difference in means between the EDT-II and R-E groups was not significant.

Insert Table 3 about here

Table 4 shows the mean number of errors on the delayed posttest for each treatment group by blocks and order. The between treatment group's main effect was significant ($F = 14.11$, $df = 2/72$, $p < .01$) and the trials or (order of presentation) main effect approached significance ($F = 3.03$, $df = 2/144$, $p < .06$). There was a slight increase in the mean number of errors across trials. For the letter combinations presented first the mean was 4.8; second, 5.3; and third, 5.5. None of the other main effects or interactions were significant. The post hoc analysis of differences between treatment groups indicated that the mean of 1.6 errors for the EDT-I group was significantly less than the mean of 7.3 for the EDT-II group ($p < .05$) and 6.6 for the R-E group ($p < .05$). These results indicate that children who were taught using the errorless discrimination training approach which involved highlighting the distinctive feature of the letter made fewer errors one week after training as compared to the R-E and EDT-II groups. These results were consistent with those obtained on the posttest given immediately after training.

Insert Table 4 about here

Discussion

According to the results of the present study the effectiveness of errorless discrimination training depends on whether or not the obvious cue is used to highlight a relevant or irrelevant dimension of the letter to be discriminated. Using a match-to-sample visual discrimination task, the children in the EDT-I group, where the obvious cue highlighted the distinctive feature of the letter, made fewer errors on the two posttests as compared to the EDT-II and R-E groups. During training only the EDT-I group made significantly fewer errors than the R-E group. The number of errors made by the EDT-II group during training did not differ significantly from either the R-E or EDT-I groups.

It is difficult to explain why only the EDT-I group made significantly fewer errors during training. It was anticipated that both errorless training groups would make fewer errors during training as compared to the R-E approach. One possible explanation as to why the EDT-II group made more errors during training is that the red strip under the letter appeared incidental to the task. It seemed that the children didn't know if they should attend to the red strip or the letter and as a result of this confusion they didn't relate the obvious cue with the correct letter. This explanation is highly speculative and needs further study before any definite conclusions can be drawn.

These results have theoretical importance as well as practical value, particularly when applied to the early stages of learning how to read. Theoretically, the results indicate that it is not necessary for a child to make errors in the process of learning the distinctive features of difficult-to-discriminate stimuli. The argument that the child must make a number of errors in order to eliminate responding to the irrelevant dimensions of the discriminative stimulus in a match-to-sample task is not valid according to the results of the present study. It was obvious that when many of the children in the R-E group made the correct choice they did not know why it was correct, and when they selected the wrong letter they had difficulty understanding why it was wrong. Many of the children in the R-E group had considerable difficulty learning the distinctive feature that differentiated the two letters just on the basis of experimenter feedback, indicating that the use of extinction is relatively inefficient as a teaching technique rather than a necessary part of the teaching process.

A second concern of theoretical interest has to do with the transfer of stimulus control from the highlighted cue used during training to the distinctive feature of the discriminative stimulus. The children in the EDT-I group did not have any difficulty transferring stimulus control from the highlighted cue to the discriminative stimulus. The highlighted cue in the EDT-I group was effective in getting the children to focus on the distinctive feature of the letter. From the results of the present study it was impossible to determine if stimulus control was transferred from the irrelevant obvious cue used in the EDT-II group to the distinctive feature of the letter.

Errorless discrimination training has educational value as a technique for dealing with many of the problems young children have in learning to discriminate letters or words. The child's failure to learn visual discriminations is often due to the fact that he is not attending to the relevant dimension of the discriminative stimulus. Zeaman and House (1963) reported that the longer period of chance performance for mentally retarded subjects on an object choice discrimination task was due to an attentional deficit. Once the retarded subjects attended to the relevant dimension, they were able to learn to make the correct discrimination in about the same number of trials as the normal subjects. One way of dealing with the difficulty many retarded, learning disabled and young children have in discriminating letters would be to teach these children to identify the distinctive feature of the discriminative stimulus. Intervention at the preschool and kindergarten level using an errorless training technique to highlight the relevant dimension offers a promising solution to this problem.

Table 1

Experimental Design

Treatment Group	Sequence	Block I N = 54 Order - Letter Combinations presented: First	Second	Third	Block II N = 54 Order - Letter Combinations presented: First	Second	Third
	1	*Q-O	K-X	Y-V	M-N	R-P	G-C
	2	Q-O	Y-V	K-X	M-N	G-C	R-P
	3	K-X	Q-O	Y-V	R-P	M-N	G-C
EDT-I	4	K-X	Y-V	Q-O	R-P	G-C	M-N
	5	Y-V	Q-O	K-X	G-C	M-N	R-P
	6	Y-V	K-X	Q-O	G-C	R-P	M-N
EDT-II	Same as above				Same as above		
R-E	Same as above				Same as above		

Note: The Q, K, and Y served as the standard for the match-to-sample discrimination task in Block I and M, R, and G were the standards for the discrimination problems in Block II.

Table 2

Mean Number of Errors during Training by Treatment Groups, Blocks, and Order

Treatment Group	Block I Order - Letter Combinations presented:			Block II Order - Letter Combinations presented:		
	First	Second	Third	First	Second	Third
EDT-I	5.7	5.8	6.3	3.9	2.6	2.1
EDT-II	9.8	13.4	12.6	11.2	12.5	13.9
R-E	13.4	18.3	16.6	16.3	17.9	17.8

Table 3

Mean Number of Errors on the Immediate Posttest by Treatment Groups, Blocks, and Order

Treatment Group	Block I Order - Letter Combinations presented:			Block II Order - Letter Combinations presented:		
	First	Second	Third	First	Second	Third
EDT-I	4.2	3.8	3.2	2.2	1.9	1.3
EDT-II	7.1	7.4	8.3	7.7	7.8	7.3
R-E	5.6	7.6	6.9	7.2	7.7	7.3

Table 4

Mean Number of Errors on the Delayed Posttest by Treatment Groups, Blocks, and Order

Treatment Group	Block I Order - Letter Combinations presented:			Block II Order - Letter Combinations presented:		
	First	Second	Third	First	Second	Third
EDT-I	2.0	2.3	2.6	0.8	1.1	0.8
EDT-II	6.2	7.7	8.0	6.9	7.2	7.7
R-E	5.8	6.6	6.1	6.8	6.9	7.7

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