FADING PROCEDURES AND CONDITIONAL DISCRIMINATION IN CHILDREN¹

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A discrimination reversal task followed by a conditional discrimination problem was administered to children (age range 36 to 107 months). A fading procedure was used during the discrimination reversal training of some subjects and other subjects were trained by a traditional procedure. More subjects trained by the fading procedure performed without errors during training and more subjects in the traditional group solved the conditional discrimination problem.

Terrace (1963a) used fading procedures to demonstrate that operant discrimination of colors could be established in pigeons without responding in the presence of a negative stimulus (S- responding). In a further experiment, also using fading procedures, pigeons' color discriminations were transferred with no errors to a more difficult line-orientation discrimination (Terrace, 1963b). Moore and Goldiamond (1964) attempted to establish errorless visual form discrimination with preschool children by using a fading procedure. While all of their subjects made some errors, they interpreted their results as suggesting that the fading procedure materially reduced S- responding. Sidman and Stoddard (1967), using retarded children as subjects, further demonstrated the effectiveness of fading procedures in establishing form discrimination. In that study, some retarded children were taught to discriminate a circle from ellipse by the use of a fading technique; other retardates were exposed to the training program without the fading technique. More fading-group subjects learned the discrimination than did non-fading group subjects; subjects in the fading group also tended to make fewer errors than subjects in the non-fading group.

The importance of such stimulus-shaping procedures for educational technology has

been discussed by a number of writers (e.g., Holland, 1960, p. 279; Sidman and Stoddard, 1967, p. 14). It has been argued that a technology that generates errors is likely to be less effective for teaching than a shaping technology that reduces training errors. The clear implication of these arguments is that the reduction of S- responding during training is likely to facilitate transfer to tasks related to the training tasks.

The present experiment was designed to investigate the effect of using fading procedures during discrimination reversal training upon subsequent solution of a conditional discrimination problem. The general format of training and testing was adapted from a series of earlier experiments (Lashley, 1938; Gollin, 1964; Gollin, 1965; Gollin 1966; Gollin and Liss, 1962). In these experiments, subjects were trained to respond to one of a pair of cues presented simultaneously on a common background. When criterion was reached on the original discrimination training, the same pair of cues was then presented on a different common background and the positive (S+) and negative (S-) values of the cues were reversed. After criterion was reached on the second task, the test of conditional discrimination was administered. The cue-background combinations were presented in a random order. Success in the conditional discrimination task required the subject to respond to the cue-background combinations which were reinforced during original and reversal discrimination. Children younger than 5 yr of

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age have difficulty solving this conditional discrimination problem unless practice on original and reversal discrimination is distributed over time, or correction procedures have been utilized during training. When training is distributed, children as young as 4½ yr are able to solve the conditional discrimination problem (Gollin, 1965). When correction procedures are introduced during original and reversal discrimination, children as young as 3½ yr have been able to solve the conditional discrimination problem (Gollin, 1966).

In the present experiment, original and reversal discrimination were given to some children using fading techniques and to other children as a traditional discrimination problem. The test of conditional discrimination for both training groups was identical.

METHOD

Subjects

Fifty-two children from nursery and elementary schools in Yellow Springs, Ohio, ranging in age from 36 to 107 months, were used.

Apparatus

The apparatus consisted of a two-window display box. The masonite face was 18 by 24 in. with two 4.5-in. square windows constructed of rear projection screen Plexiglas. The windows were horizontally aligned with a 2.75-in. space between them and centered vertically. A red pilot light was centered 1 in. above each window. There were 52 stimulus slides. Each slide contained two patterns on a dark gray background. The slides were projected from behind, by a modified Carousel projector (Campbell and Gollin, 1967), with one pattern falling on each window. Subjects responded by pressing one of the windows. A correct response turned on the red signal lamp above the appropriate window. The lamp and slide remained on after the response for 0.5 sec. After a 2.5-sec dark interval the next pair of stimulus patterns appeared. If the S- window was pressed, the same time relations obtained as when the S+ window was pressed but the red light over the window remained off. A Rustak four-channel event recorder was used to record responses.

Procedures: All Subjects

The child was brought into the experimental room, shown an array of toys, and told that he could have a toy after playing a game. The child was then seated in front of the apparatus. The experimenter said, "In this game you are going to try to make a red light go on." The first set of stimuli was presented and the experimenter said, "Which picture do you think will make the red light go on?" After the child indicated one of the windows, he was told to "push the window". If he chose the correct pattern, the red light came on over that pattern, the stimuli went off, and the projector advanced to the next stimulus pair. The experimenter urged the child to "try to make the light go on every time". If the child pushed the wrong window there was no red light, the stimuli went off, the projector presented the first slide again, and the experimenter said, "The light didn't go on that time. Try the other window." After the first trial the experimenter made no further comments.

Each child was presented with three successive tasks: original discrimination, reversal discrimination, and a test of conditional discrimination. Throughout original discrimination and reversal discrimination, if the child pressed the S- window the projector drum backed up so that the next stimulus pair presented was the one which had preceded the pair upon which the error was made. Thus, each error extended the session by two trials. It was possible for the child to "go back" through the series at any point before the test of conditional discrimination. The back-up contingency was not used during the conditional discrimination test series. Thus, all subjects had 12 conditional discrimination trials. The left-right position of S+ was determined by a Gellerman order in all three phases.

Stimulus Patterns:

Original Discrimination and Reversal Discrimination

1. *Fading groups.* Figure 1 shows the full brightness condition of the stimulus displays.² In Series I on trial 1, S+ (triangle, sin-

²Details of construction of the stimulus patterns and slides have been deposited as Document number 9944 with the ADI Auxiliary Publications Project, Photoduplication Service, Library of Congress, Washington,

SERIES I

SERIES II

Fig. 1. The stimulus patterns in the full condition.

gle stripe) appeared at full brightness in one of the windows. The other window was blank (very dark gray in appearance). S+ remained (both triangle and stripe) at full brightness throughout the run. S- faded in as follows: trial 1 was blank; on trials 1 through 10 the circle faded in from barely discernible gray to full brightness; on trials 11 through 19 the cue (circle) was maintained at full brightness and the single stripe faded in from barely discernible to full brightness. On trials 19 and 20, S+ and S- (background stripes included) were at full brightness. Exactly the same arrangement was used for Series II, in which the circle and its accompanying multiple

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Fig. 2. Illustration of a few steps in the Series II fading procedures. S+ remains at full brightness throughout with the S- cue fading in from dark gray to full brightness followed by S- stripes fading from dark gray to full brightness.

Table 1
Descriptive Characteristics of Subjects Training Condition

<i>Fading</i>			<i>Traditional</i>		
<i>Subject</i>	<i>CA (months)</i>	<i>Sex</i>	<i>Subject</i>	<i>CA (months)</i>	<i>Sex</i>
A	36	F	a	63	F
B	48	F	b	65	M
C	50	F	c	65	M
D	54	M	d	65	M
E	57	M	e	66	F
F	64	M	f	66	F
G	66	F	g	66	M
H	70	F	h	69	F
J	72	M	i	69	M
K	72	F	j	73	M
L	107	F	k	82	F
M	43	F	l	94	F
N	47	F	m	106	F
O	52	F	n	60	M
P	52	F	o	62	F
Q	54	F	p	70	M
R	57	M	q	72	F
S	58	M	r	73	F
T	65	M	s	84	F
U	65	F	t	84	F
V	66	F	u	85	F
W	68	M			
X	69	M			
Y	69	F			
Z	78	M			
AA	84	F			
BB	96	M			
CC	60	F			
DD	66	M			
EE	48	F			
FF	60	F			

stripes (S+) appeared at full brightness throughout, the triangle (S-) faded in from trials 2 through 10, and the multiple stripes accompanying the triangle faded in from trials 11 through 19. Figure 2 contains a schematic illustration of a few steps in the Series II fading procedure.

Series I (20 slides) served as the original discrimination stimuli and Series II (20 slides) as reversal discrimination stimuli for 11 subjects; this order was reversed for 16 subjects.

2. *Short-form fading groups.* For this group the number of fading steps was reduced by removing every other slide from the original and the reversal discrimination series used for the fading group. This shortened both series to 10 slides each.

Two subjects received the Short-Form Series I for original discrimination and the Short-Form Series II for reversal discrimination: this order was reversed for two subjects.

3. *Traditional groups.* All stimulus patterns

presented to the traditional groups appeared at full brightness (white on dark gray background) throughout original (20 slides) and reversal (20 slides) discrimination.

Series I (full brightness) served as original discrimination stimuli and Series II (full brightness) as reversal discrimination stimuli for 13 subjects; this order was reversed for eight subjects.

Stimulus Patterns:

Conditional Discrimination Test

All subjects received a 12-slide conditional discrimination test. In this test all stimulus patterns were at full brightness. Success in the test required a response to the cue-stripe combination that had been reinforced during original discrimination and reversal discrimination. Each cue-stripe condition appeared six times. The sequence of appearance of cue-stripe conditions was random, with the following restrictions: (1) if a subject had Series

II for reversal learning then the first conditional discrimination pattern for that subject was the Series I pair and *vice versa*; (2) cue-stripe runs were two or less.

RESULTS AND DISCUSSION

Subjects' designations, ages and sex are contained in Table 1.

Fading group. Performances of subjects in the fading groups are shown in Fig. 3. The two youngest children, Subjects A and M did not complete reversal discrimination in the usual fashion. A became fixated on a left-position response during reversal discrimination, and M showed a tendency to erratic alternation behavior. The "back-up" contingency was eliminated for these subjects (see

asterisks in Fig. 3) so that they might reach the conditional discrimination task.

The efficacy of fading procedures for producing errorless responding is demonstrated by subjects F, L, N, O, P, U, and X, who completed the original discrimination without error. Of the subjects who made zero errors on original discrimination, only one (U) showed errorless performance on reversal discrimination. Subject R, who made two errors very early in the original discrimination series, went through reversal discrimination without any S- responding and also was errorless on the conditional discrimination task. R was the only subject to complete the conditional discrimination test without error.

On the conditional discrimination task, two or fewer errors were required for a perform-

Fig. 3. Accuracy of response during original discrimination, reversal discrimination, and conditional discrimination test for subjects presented with the complete fading procedure. Bold face numerals indicate number of errors. Arrows indicate shifts from original to reversal discrimination, and from reversal discrimination to conditional discrimination test. Asterisks indicate the point at which the "back-up" contingency was eliminated (see text). Letters designate individual subjects (age and sex appear in Table 1).

Fig. 4. Accuracy of response during original discrimination, reversal discrimination, and conditional discrimination test for subjects presented with the short-form fading series (see text). Bold face numerals indicate number of errors. Arrows indicate shifts from original to reversal discrimination and from reversal discrimination to conditional discrimination test.

ance to be significantly different from chance at the 0.01 level of confidence; subjects C, L, R, T, AA, and BB attained that level of performance. The remaining subjects did not achieve error scores significantly different from chance at the 0.01 level.

Five subjects reversed without error, R, S, U, Z, and AA; of these only R and AA achieved a better-than-chance performance on the conditional discrimination test.

Short-form fading. An attempt was made to increase the efficiency of the training phases by reducing the number of fading steps. Accordingly, four subjects were presented with an original and reversal discrimination series in which every other slide had been removed. Although Terrace (1966) suggested that enlarging the steps in the progressive change of S- might produce increased S- responding, it was possible that shortening the training discriminations might facilitate transfer to the test of conditional discrimination, since the transfer task would be administered sooner in

time after the original discrimination was completed.

The results of the shorter fading series groups are shown in Fig. 4. Subjects CC and DD were given the Series I order and Subjects EE and FF were given the Series II order. Decreasing the number of fading steps in original and reversal discrimination did not produce any noticeable increase in S- responding, nor any facilitation of transfer to the conditional task.

Traditional groups. Performances of the subjects trained by traditional procedures are shown in Fig. 5. Subject m did not complete the original discrimination task. After 73 trials the "back-up" mechanism was turned off. Subject m made 12 errors during reversal discrimination and five errors on the conditional task. Subjects q and p were errorless during original discrimination and subject f made zero errors during reversal discrimination. Eight subjects, b, c, h, i, p, s, t, and u, achieved errorless performance on the conditional dis-

Fig. 5. Accuracy of response during original discrimination, reversal discrimination, and conditional discrimination test for subjects in traditional groups. Bold face numerals indicate number of errors. Arrows indicate shifts from original to reversal discrimination and from reversal discrimination to conditional discrimination test. Letters designate individual subjects (age and sex appear in Table 1).

crimination test. In addition, five other subjects, d, j, k, g, and r made fewer errors than would be expected by chance at the 0.01 level of confidence.

Comparisons of Fading and Traditional Procedures

Subjects A and M of the fading group and Subject m of the traditional group were excluded from the comparisons because they were exposed to altered training procedures.

A larger percentage of the subjects in the fading group (28%) than in the traditional group (10%) made zero errors during the original discrimination. More subjects in the fading group (20%) than in the traditional group (5%) were errorless during the reversal discrimination.

On the test of conditional discrimination, 40% of the subjects in the traditional group

performed without error, compared with 4% of the fading group. If the comparative analysis is extended to include all those subjects who made fewer conditional test errors than would be expected by chance at the 0.01 level of confidence, the advantage for the traditionally trained subjects over the subjects trained by fading procedures is maintained. The respective percentages for the two groups were 65 and 24. Thus, it appears that subjects trained by the fading procedure are more likely to perform errorlessly during original and reversal discrimination, while subjects trained by the traditional procedure are more likely to succeed during the transfer task of conditional discrimination.

An analysis of total error scores was also conducted (see Fig. 6). Subjects under 64 months in the fading group were excluded from the analysis so that age ranges of the

Fig. 6. Error distributions of the two experimental groups in the three phases of the experiment.

groups were comparable: for original learning $U = 135$, Not Significant; for reversal learning $U = 147.5$, Not Significant; for conditional discrimination $U = 78.5$, $p < 0.02$, two-tailed, indicating the superior performance of the traditionally trained group.

There was no indication that absence of S—responding by a subject during original discrimination was associated with a reduction of S—responding during reversal discrimination.

The success of the majority of subjects in the traditional group on the conditional discrimination test suggests that in transfer paradigms of the type used in the present experiment, access to S+ and S— compounds throughout training can be efficacious. The gradual introduction of the S— compound in the fading procedure may not provide the subject with sufficient comparative experience to permit efficient transfer. Efficient transfer may require the establishment of a dimension schema which then serves to mediate the subject's observational techniques in a manner that insures more complete apprehension of the properties of the stimulus field. If the subject learns to respond to the "smaller" or the "rounder" or, as in the present case, one of several compound stimulus patterns, then in the transfer task his attentional responses

are more likely to lead to successful performance. Should fading techniques tend to confine the subject's attentional responses to specific attributes of S+, the subject is likely to be at a disadvantage when a transfer task is introduced, since those stimulus properties which have been reinforced early in the fading procedure are likely to control response. If the control is strong then the subject may not attend to other stimulus properties as they become manifest and, therefore, he may not acquire the attentional responses necessary for efficient transfer.

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