

ERRORLESS ESTABLISHMENT OF VISUAL DISCRIMINATION USING FADING PROCEDURES¹

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A visual discrimination task involved presenting a triangle briefly as a sample. When it was withdrawn, this triangle and two others differing slightly in degree of rotation were presented in different positions, with *S* required to locate the sample that had been presented. Discrimination proved difficult for preschool children. When only the correct triangle was illuminated, discrimination was readily established. The brightness difference between correct and incorrect matches was gradually faded out by increasing the intensity of the incorrect matches, until they were equal in brightness to the correct match. The discrimination established by brightness difference was maintained in its absence, thereby transferring stimulus control from brightness to form, in an almost errorless sequence.

In laboratory discrimination experiments, the establishment of discrimination often requires numerous extinction trials. In programmed instruction (Holland, 1960), on the other hand, the experimental aim is to program the presentations to preclude such trials, which are considered to be "errors." In the present investigation, such errorless procedures were applied to a laboratory situation to minimize *S*^A responding, using preschool children as *Ss*, in a task involving form discrimination.

The procedure is adapted from an experiment by Terrace (1963), who minimized the considerable *S*^A responding previously associated with the establishment of responding to vertical rather than horizontal stripes by pigeons. The easier discrimination between red and green was first established. Each stripe was then embedded in a color, and the colors were then gradually faded out. The discrimination was transferred to the stripes alone almost without error.

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METHOD AND PROCEDURES

Six children attending private day nursery schools⁴ served as *Ss*, with ages (to the nearest year), and sexes as follows: S-1, 3F; S-2, 5M; S-3, 4F; S-4, 5F; S-5, 4M; S-6, 4M. They were children of working mothers, engaged mainly in clerical tasks (with one nurse and one teacher); the fathers included clerical, maintenance, and skilled industrial workers. The experiment was conducted in a special room at the nursery schools set aside for that purpose.

The *S* faced a masonite panel, about 24 in. square, containing four small windows, each of milk plastic, 2 in. wide by 3 in. high. The sample window was centered toward the top of the panel, with the other three windows symmetrically arranged in an arc below it, so that the center of each was 4 in. from the center of the sample window. Arranged in an arc beneath each of the matching windows were three small buttons, the manipulanda, with a pilot light above each. This light went on when the correct button was pressed.

Two types of series were run, *full* presentations and *fading* series, for the same or different *Ss*. In the full presentations, the sample window at the top went on, projecting a triangle at full 110v intensity. The sample window then went off, and simultaneously, the

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current was switched to the three matching windows below, each of which contained a triangle presented at full 110v intensity. One of these was matched in degree of rotation with the sample triangle, and the other two differed. The *S* was required to select the one that matched the withdrawn sample, a delayed matching to sample task (Ferster and Appel, 1961). In the fading series, the sample window was presented and withdrawn, as in the full series, but of the three windows, only the correct match was presented at full 110v intensity, the two incorrect matches being presented at a lower intensity, ranging from 0 up. This distinction between correct and incorrect was enhanced by a marked phi-phenomenon effect as the current was switched from the sample to the correct matching window. This series began with three presentations of the incorrect windows at 0, then one presentation each at settings .35, .40, .50, .60, .65, .70, .75, .80, .83 (or .82), .86, .88, .90, .92, .94, .96, .98 of full voltage. There were then at least seven presentations at 1.00 (110v) in this series. It will be noted that at this final level, the settings are identical to those of the full series, and that the gradual increase in voltage, whereby this identity is produced, represents a gradual fading of the brightness difference between incorrect and correct, since the latter is always presented at full intensity. A correct response advanced the presentation to the next in this series; an incorrect response resulted in a repetition of the step (with a new slide). Two consecutive errors resulted in a regression to a previous step.⁵

Three triangles differing in angle of rotation were used as stimuli (Reynolds, 1961). They were inverted isosceles skeleton triangles, altitude 1.75 in., base 1.25 in. centered in each window. The apex was either straight down (D), rotated 25° to the left (L), or to the right (R). All three appeared in the matching windows, in varied positions; the sample was also varied. The order of sample presentations (with match presentations in parentheses) was: L (LDR), D (RLD), R (LRD), L (RDL), D (DRL), R (DRL), R (RDL), L (DLR), D

(LDR), recycle. Nine sheets of acetate formed the slides, which incorporated these presentations. They were inserted into position before each presentation, with all lights off.

The *S* faced the panel, with *E* visible at the side, and with controls behind the panel. The sample was illuminated for approximately 4 sec as *S* was told: "Look at the picture in the top window. See which way it's pointing." It was then turned off, illuminating the matching windows, and *E* said: "Find another pointing the same way; touch it and push the button underneath it." If a correct response was made, the pilot light above the button illuminated immediately, and *S* was handed a small consumable or trinket, which he had previously been instructed to put into a small plastic bag. If an incorrect response was made, nothing was said by *E*. Recording was manual.

RESULTS

Results are presented in Fig. 1. The ordinate is cumulative correct responses, and the abscissa is number of presentations. Establishment of discrimination by the fading schedule is most clearly demonstrated by the curve for *S*-1, who was begun on the full series, with incorrect windows at voltage setting 1.00. Accuracy was no better than chance. At A, fading was introduced, with the incorrect windows set at 0. These were then increased in voltage to .60, at B. All responses in this series were accurate. The brightness differences between correct and incorrect were then eliminated, with the full series replacing the fading series, from B to C, during which the settings of the incorrect windows were 1.00. Accuracy immediately deteriorated to chance values. At C, fading procedures were reintroduced, with the voltage setting at .60, where it had been before the total elimination of differences between the windows. Accuracy immediately returned, with only two errors occurring during the ascending voltage (but decreasing brightness difference) series. At D, the voltages of all three matching windows were the same, and it will be noted that accuracy was maintained under conditions where previously (the full series) it had been no better than chance. Stimulus control had been transferred from brightness to rotation.

Contrasting effects upon the establishment of discrimination using full and fading series

⁵In four *S*s, the fading series was extended between two and four presentations by unsystematic errors by *E*, which seemed to have no effect upon the data. These errors included repeating the voltage of the preceding presentation, and increasing by steps of .05 where .10 was scheduled.

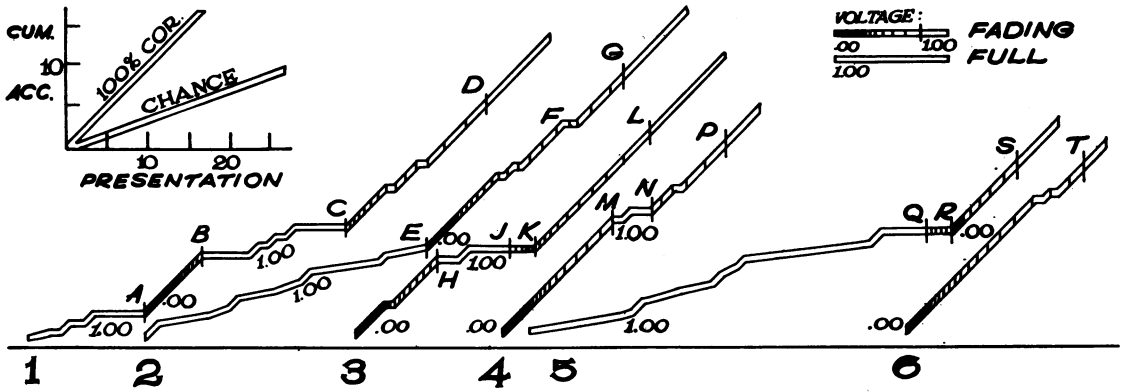


Fig. 1. Accuracy rates as functions of differential reinforcement of correct and incorrect matches of triangles when presented at full intensity during training (Full), as compared to initial presentation at differing intensities for correct and incorrect matches, with the difference gradually faded out (Fading), by increasing the intensity of the incorrect matches until they were as full as the correct matches.

are also demonstrated by S-2, who was begun on the full series, with accuracy no better than chance. At E, fading was introduced, with the incorrect windows set at 0. Discrimination immediately became errorless. At F, there were two errors in a row, and the voltage was lowered one step. Accuracy returned, and the progression was reinstated, culminating in 1.00 at G, when the incorrect and correct windows were equal in brightness, the condition prior to E. In contrast to the latter period, which was under the full series, discrimination is now maintained without error.

The fading procedure initiated the sessions of S-3 and S-4, who accordingly began with errorless discrimination trials. For S-3, at H, the setting was .75, and the next settings were at 1.00, the full series, instead of .80 of the fading series. There was an immediate deterioration in accuracy. At J, the .75 setting was re-introduced, with no appreciable effect upon accuracy. The settings were then progressively reduced to .70, .65, and .60, at which point accuracy was reinstated (K), and the progression reestablished, with accuracy continuing thereafter through L, at the final setting of 1.00. For S-4, setting .82 was followed by full voltage at M, with breakdown to chance performance. Reinstatement of the fading procedure at N, when the setting was returned to .82, was followed by recovery of accuracy, which continued with one error into P, at the final setting of 1.00.

For S-5, the series was begun at full setting, with the chance performance characteristic of this procedure evident. At Q, the incorrect

windows were lowered to .60 rather than 0, with no appreciable effect upon accuracy. At R, accordingly, fading was introduced by setting the incorrect windows at 0, with the complete reinstatement of accuracy which characterized this procedure. For this S, however, the fading series comprised three presentations at 0, four at .60, and six at 1.00. Errorless behavior was maintained during transitions whose abruptness disrupted discrimination in the other Ss. Whether such behavior was a function of the individual S, or of the long standard discrimination training period prior to Q, which characterized this record, and during which some discrimination may have been established, cannot be answered from these data. The record certainly contrasts, however, with that of S-6, who was begun using the fading procedure, and was continued on it without interruption. By T, the progression had reached 1.00 and was maintained without error. Discrimination was established with only two errors, and in the minimal time. His condensed performance contrasts sharply with that of the other Ss, and the similarities of his record to those of other Ss during fading series, prompt the suggestion that it was the fading procedures themselves that were involved in the rapid establishment of discrimination.

DISCUSSION

These results indicate that fading procedures may be extended to the errorless establishment of discrimination in matching to

sample procedures.⁶ Errors produce extinction trials which may make it more difficult to maintain the behavior being studied and serve to prolong the series. The economy of procedures which minimize error was depicted in the last *S* presented, whose learning was the most "perfect," with the least practice. Control of errorless behaviors by the procedures themselves was evident throughout the experiments by the reversibility and reinstatement obtained when the fading procedures were systematically dropped or instated. The results also reiterate that a major variable in the establishment of behavior is the sequence (or program) of procedures utilized. On the response side, attention to sequence characterizes shaping, which can be considered a program of reinforcement of successive response ensembles, the succession being dictated by increasing presence of behavior along a criterion dimension. Thereby, novel response patterns are established, either for their own sake, or for use in other research. Analogously, in

fading, *E* reinforces responses to stimulus differences successively approaching a criterion stimulus dimension. It is suggested that such procedures may be useful to establish novel discriminations and others required in psychophysical or other perceptual (*cf.* Goldiamond, 1962) or conceptual research (Goldiamond, in press).

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⁶Discrimination of selected letters of the alphabet, using parallel fading procedures, was also established without error with other children from the same nursery schools.