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Enhanced learning of new discriminations after stimulus fading

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Humans learned to name three sets of braille patterns presented visually. After learning a practice set by traditional discrimination training, half the subjects learned a new set by fading, and the remaining subjects learned them by traditional discrimination training. Finally, all subjects learned a third set of new patterns by traditional discrimination training. Subjects who learned the second set by fading learned the third set faster than did subjects who learned the second set by traditional means. This effect was explained in terms of the differential strengthening of observing behavior by fading and by traditional discrimination training.

To what extent will a history of errorless learning influence the learning of subsequent discrimination? The question was addressed by using transfer designs in which an initial discrimination had been established by traditional discrimination training or by procedures that produced errorless acquisition of stimulus control. A subsequent discrimination was established by traditional discrimination training. Differences in learning the subsequent discrimination were then attributed to the procedures used to establish the stimulus control in the initial discrimination and/or to the by-products of initial training that would generalize to the subsequent discrimination.

Cheney and Stein (1974), Gollin and Savoy (1968), Robinson and Storm (1978), and Schilmoeller, Schilmoeller, Etzel, and LeBlanc (1979) used a variety of procedures to establish stimulus control errorlessly in the initial discrimination. In some cases, enhancement of subsequent discrimination learning was observed; in others, retardation occurred. In all of the experiments, however, the same stimuli were used in the initial and subsequent discriminations. No data are available to assess the effects of a stimulus fading history upon acquisition of control by new stimuli used in subsequent discrimination. The following experiment demonstrated such an effect and provided information regarding some possible explanations of the observed effects.

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METHOD

Subjects

Eleven male and six female college students were randomly assigned to two experimental groups. Three women and six men were in one group, while three women and five men were in the other.

Apparatus

Subjects were seated at a table facing a portable motion picture screen that was 2 m away. A reinforcement counter (BRS/LVE Model 551-25) was on the table facing the subject. The letters that were the available response alternatives for each part of the experiment were printed on a cardboard strip, 7.5 cm high x 30 cm long, which rested on top of the reinforcement counter. Two Kodak Carousel projectors and a shutter to control stimulus presentations were located behind the subject.

The stimuli consisted of English capital letters and their braille equivalents, presented as black forms on white backgrounds. Letters and braille symbols were presented alone or were superimposed and presented as compounds in various parts of the experiment. When projected, the stimuli covered a field on the screen that was 42 cm high x 34 cm wide. The braille patterns were centered on the field and consisted of 5-cm dots separated by 17 cm measured between centers. Letters, also centered on the projection area, were 34 cm high, but width varied with the letter. The line width for letters was 7 cm. Braille and letter equivalents for D, G, O, and W were used in Condition A; for H, L, S, P, T, and Z in Condition B; and for J, M, U, R, V, and Z in Condition C. An equal number of braille stimuli having three or four dots were used in each condition.

Stimuli were faded in and faded out by changing the focus on the projector displaying the stimuli (Acker, 1969). The 11 levels of defocusing used in each portion of the fading procedure were measured in terms of degrees of rotation of the focusing knob of the projector.

Procedure

After entering the experimental room, the following instructions were read to the subjects: "You will be shown a series of forms on the screen which will be either letters or dot patterns or both. For each form your task will be to say the correct letter. Each dot pattern has a corresponding letter. Each time you make a correct response you will earn a point. Please make

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only one response for each presentation. The responses you may use are indicated on this letter chart [show it]. Points will be accumulated on this counter [demonstrate it]. The letter chart and the available responses will be changed for different stages of the experiment." Questions were answered by rereading the relevant portion of the instructions once. Then the room light was dimmed, and the following was read to the subject: "We are now ready to begin. When you see the first form, please make your response."

Condition A. The strip containing the response letters for Condition A was placed on the reinforcement counter, and traditional discrimination training began. On each trial, a fully focused braille stimulus was presented for 5 sec or until the subject responded by saying a letter name, after which the screen was darkened for an intertrial interval of 10 sec. Correctly naming the braille symbol was reinforced by increasing the number on the reinforcement counter by one point. The stimuli were presented in random order, with the restriction that each occurred once within every block of four presentations. Training continued until each stimulus was correctly identified twice in a row.

Condition B. The strip containing the letter names for Condition B replaced that used for Condition A. Then nine subjects learned the stimuli in Condition B by traditional discrimination training, and eight subjects learned B by fading.

B: Traditional discrimination training. When Condition B stimuli were learned by traditional discrimination training, the stimuli were presented as in Condition A. Since six stimuli were used, however, they were presented in a random order, with the restriction that each occurred once in every six-trial block.

B: Stimulus fading. When Condition B stimuli were learned by fading, subjects were presented with compound stimuli consisting of one of the letters in Condition B superimposed on the braille equivalent. Each compound was presented alone for 5 sec or until a response occurred. The temporal parameters and reinforced contingencies used in fading were the same as those used in Condition B traditional discrimination training groups. Initially, each compound stimulus consisted of a fully focused letter and a fully defocused braille equivalent. If a subject responded correctly to six stimuli consecutively, the focus of the braille components was increased by one step. One error at a fading level reset the level for a different random series. A second error resulted in a return to the previous fading level. Once the braille stimuli were completely focused (fade in), they remained so for the rest of Condition B, and the letter components were systematically defocused using the following criteria. After six consecutive correct trials, the letters were defocused by one step. One error at a fading level reset the level, and a second error was followed by an increase in the focus of the letter, by one step.

The probe stimuli consisted of the fully focused braille stimuli. Prior to each defocusing of letters, each probe stimulus was presented alone until an incorrect response occurred or until the subject responded correctly to two consecutive blocks of the braille stimuli. Subjects were reinforced for each correct response to probe stimuli. If fewer than 12 braille probes were presented, the next scheduled fading level of compound stimuli was presented. When 12 correct probes occurred, Condition B was terminated.

Condition C. After completion of either B condition, the response strip to be used in Condition C was introduced. Condition C stimuli were presented using the contingencies in effect when training Condition B in the traditional manner. Regardless of the procedure used in Condition B, all subjects learned the stimuli in Condition C using traditional discrimination training.

RESULTS

The average number of trials subjects in each group needed to learn the stimuli in Condition A did not differ significantly [$t(13) = .98$, $p > .05$]. During Condition B, subjects took an average of 66.3 trials to learn the stimuli by traditional means and made an average of 37.4 errors during acquisition. Of the eight subjects in the fading group, two satisfied the criterion of learning upon the first presentation of probe stimuli. Since they would have been overtrained relative to all other subjects, their data were deleted from consideration. The remaining six subjects took an average of 89.8 compound trials and 11.3 probe trials to reach the criterion of learning. Only .7 compound trials, on the average, were responded to incorrectly; 4.1 probe trials, on the average, occasioned an incorrect response. Thus, although more trials were needed to reach criterion using fading, far fewer errors occurred during fading than during traditional discrimination training. Subjects in both B groups, however, learned the discrimination to the same criterion.

Condition C stimuli were learned in an average of 51.4 trials by subjects with a history of traditional discrimination training. In contrast, those with a history of fading took an average of 32 trials to learn the stimuli in Condition C. The 37% enhancement of discrimination learning after fading was statistically significant [$t(13) = 2.18$, $p < .05$] and was representative of comparisons made between individual subjects who were matched according to their performances in Condition A, as illustrated in Figure 1.

Figure 1 presents the difference in the number of trials needed for each subject to learn the third discrimination (Condition C) and the first discrimination (Condition A). Comparisons were made between subjects who had learned the first discrimination within 10 trial subcategories. If more trials were needed to learn C than to learn A, (C − A) was positive; if fewer

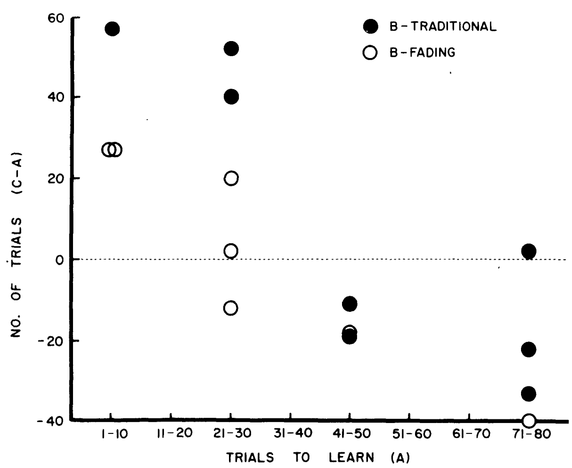

Figure 1. Difference in number of trials to reach criterion for learning in Conditions A and C for each subject who learned B by fading and B by traditional training. Data do not include the criterion run of trials.

trials were needed to learn A than to learn C, (C − A) was negative.

When A was learned in 30 or fewer trials, the stimuli in Condition C acquired control in more trials than did the stimuli in Condition A. A smaller increment in number of trials to learn C was needed, however, when B was learned by fading instead of traditional discrimination training. When A was learned in more than 30 trials, the stimuli in C acquired control in fewer trials than did the stimuli in A. A greater decrement in number of trials to learn C, however, occurred after learning B by fading than by traditional discrimination training, with only one exception. Regardless of speed of learning the initial discrimination, a new discrimination was learned in relatively fewer trials after fading than after traditional discrimination training.

Enhanced learning in C was also observed when comparing subjects who learned B in an equivalent number of trials. Four subjects learned the Condition B stimuli by fading in 72-96 trials. Three subjects learned the Condition B stimuli by traditional means in the same range of trials. Subjects who learned B by fading learned Condition C stimuli in an average of 27.8 trials; those who learned B by traditional discrimination training learned Condition C stimuli in an average of 58.3 trials, a statistically significant difference [$t(5) = 3.106$, $p < .05$]

DISCUSSION

A history of stimulus fading enhanced the learning of a subsequent discrimination. Such results have been reported previously, by Robinson and Storm (1978) and Schilmoeller et al. (1979), where the same stimuli had been used in the initial and subsequent discriminations. In the current experiment, however, different stimuli were used in each condition. Thus, the results extend the generality of the previously reported enhancement effect.

Although differences in learning the new discrimination in Condition C could be attributed to a number of factors that distinguished the learning of B by fading or traditional discrimination training, many of these are unlikely explanations of the reported enhancement effects. For example, enhancement could be attributed to differences in stimulus exposure while learning the Condition B discrimination. Specifically, since subjects were trained to the same level of stimulus control when fading and traditional discrimination training were used, the number of stimuli had to vary freely. Because more trials were presented during fading than during traditional discrimination training in Condition B, it could be argued that the difference reported in Condition C was due to the difference in the number of stimulus exposures during B. Such an alternative, however, can be questioned for two reasons. First, if stimulus exposure in B was a determinant of performance in C, subjects who learned B in an equivalent number of trials should have learned C in a like number of trials, regardless of the procedure used to learn B. When subjects who had learned the stimuli in Condition B by fading and traditional training in an equivalent number of trials were compared, however, those with a history of fading learned Condition C faster than did those who learned B by traditional discrimination training. Second, since the original controlling stimuli in fading exert a blocking function, subjects probably do not attend to the new stimuli throughout fading (Fields, 1978, 1979; Fields, Bruno, & Keller, 1976; Kamin, 1968). Therefore, it is probable that the number of stimulus presentations is not a reliable index of functional exposure to the new stimuli in B. Differences in C, then, cannot be clearly attributed to differences in stimulus exposure during traditional discrimination training and fading in Condition B.

Another alternative is that enhancement was due to the errorless nature of stimulus control acquisition per se during initial discrimination training. Such an explanation is questionable, however, since Cheney and Stein (1974), Gollin and Savoy (1968) and Schilmoeller et al. (1979) each demonstrated conditions in which acquisition of stimulus control in a subsequent discrimination occurred more slowly after a history of fading than after traditional discrimination training.

A more plausible account of the enhancement effect, however, can be developed by considering how observing behavior (Wyckoff, 1969) may have been strengthened by fading and traditional discrimination training in Condition B and then carried forward to Condition C. In discrimination training, a stimulus is presented, an observing response occurs, response-produced cues that place the subject in contact with specific characteristics of the stimuli are generated, a reporting response occurs, and a reinforcing stimulus may be presented (Mackintosh, 1965; Schoenfeld & Cumming, 1963; Sutherland & Mackintosh, 1971; Zeaman & House, 1963). In the present experiment, the observing response would consist of looking at dots, the response-produced cues would be the dot patterns scanned, and the reporting response would be naming the stimulus.

Assuming that an observing response occurred on each trial in Condition B, during fading each observing response would be followed by a reinforcer, since correct naming responses occurred on each trial. During traditional discrimination training, however, only some observing responses would be followed by reinforcers, since correct naming responses occurred only on an intermittent basis. Thus, observing responses would have been reinforced continuously during fading but only intermittently during traditional discrimination training. By the end of the training in Condition B, then, observing behavior would have been strengthened more by fading than by traditional discrimination training (deLorge & Clark, 1971; Dinsmoor, Browne, & Lawrence, 1972). In Condition C, it follows that subjects should observe the relevant features of the stimuli more readily after fading than after traditional discrimination training and, thus, learn C in fewer trials after fading. Evidence supporting such an analysis linking acquisition rate to likelihood of observing behavior is provided by D'Amato, Etkin, and Fazzarro (1968), Cohen, Looney, Brady, and Aucella (1976), and Eckerman, Lanson, and Cumming (1968). Further confirmation, however, would depend upon direct measurement of observing behavior in each phase of a replication of the current experiment.

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