BEHAVIORAL CONTRAST AND THE PEAK SHIFT: EFFECTS OF EXTENDED DISCRIMINATION TRAINING¹

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Behavioral contrast and the peak shift, two widely observed phenomena in experiments on successive discrimination learning, were shown to disappear during extended discrimination training. This finding and an analysis of the conditions under which behavioral contrast and the peak shift occur suggested that both phenomena were by-products of emotional responses that resulted from response suppression and that their disappearance after extended discrimination training could be attributed to the dissipation of such emotional responses.

One frequently observed consequence of training a successive discrimination between a stimulus that is correlated with reinforcement (S+) and a stimulus not correlated with reinforcement (S-) is an increase in the rate of responding to S+ above its pre-discrimination value. This phenomenon has been referred to as "contrast" by Skinner (1938) and "behavioral contrast" by Reynolds (1961) to illustrate that the rate of responding to S+ "contrasts" with the decreasing rate of responding to S-. Another widely observed consequence of training a discrimination is a shift in the peak of a post-discrimination generalization gradient away from S- (Hanson, 1959).

Both behavioral contrast and the peak shift have been observed only in experiments in which non-reinforced responses to S- (errors) occurred during acquisition of the discrimination. When special training procedures which result in the acquisition of a discrimination without errors are used, neither behavioral contrast nor the peak shift occurs (Terrace, 1963; 1964). This led to the hypothesis that behavioral contrast and the peak shift resulted from stimulus-correlated emotional effects of non-reinforced responding, and that extended exposure to the discriminative stimuli would diminish these emotional effects. The two experiments described below sought to test this hypothesis by determining whether

extended discrimination training would result in the gradual disappearance of behavioral contrast and the peak shift.

EXPERIMENT I

Method

The subjects were eight experimentally naive White Carneaux pigeons maintained at 80% of their free feeding weight throughout the experiment. The apparatus was a standard operant conditioning chamber (Ferster and Skinner, 1957) in which the response key could be transilluminated by light that passed through one of 15 Bausch and Lomb filters, each having a half-width of less than 12 m μ .

The wavelength of the stimulus correlated with reinforcement was always 580 m μ . After the first session, during which the key-peck response was conditioned, responses were reinforced on a 1-min variable interval (VI 1) schedule. At the end of each minute a shutter interrupted the beam of monochromatic light for 2 sec to prepare the birds for discrimination training and generalization testing sessions during which the 2-sec time out (TO) would be used for changing filters. Responses to the dark key were never reinforced.

Discrimination training started with the 15th session. S+ and S- (540 m μ) were presented alternately, in random succession, and were each followed by a 2-sec TO. Each presentation of S+ lasted 1 min. The duration of an S- presentation was also 1 min, unless responses to S- occurred. Each response to S- delayed termination of the current S- for 30 sec. This procedure insured that re-

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sponses to S— could not be secondarily reinforced by the subsequent appearance of S+. All sessions (except the first shaping session) were terminated after 25 reinforcements.

After 60 daily discrimination sessions, B-36, B-38, B-40, and B-44 were given a generalization test. During the test, 15 stimuli (wavelengths of 490, 510, 520, 530, 540, 550, 560, 570, 580, 590, 600, 610, 630, 650, 670 m μ) were presented in four random sequences. Each stimulus was presented for 1 min. Responding was not reinforced.

Results

The left-hand portion of Fig. 1 shows the rate of responding to S+ of each subject during the 14 pre-discrimination sessions and the subsequent 60 discrimination training sessions. Behavioral contrast was observed in each subject, *i.e.*, the rate of responding to S+ increased at the start of discrimination training. Not shown in Fig. 1 are the rates of responding to S—. Subjects B-36, B-38, B-40, and B-44 each made a total of 2222, 3368, 1691, and 2602 responses to S— respectively. The number of responses to S— per session was, in each case, less than 18 by the end of the 17th session. In no instance did the number of responses to S— exceed 14 during the remaining discrimination sessions.

The dashed horizontal lines in the left-hand portion of Fig. 1 indicate each subject's average rates of responding during the last four VI and VI Ext sessions. A comparison of the rate of responding to S+ at the end of the 60th discrimination session with the rate of responding to S+ immediately before discrimination training, shows that the elevated rate of responding to S+ tends gradually to decrease to its pre-discrimination level. These data, and the results of a similar pilot experiment (Terrace, 1966, p. 323), demonstrate that behavioral contrast is not a permanent characteristic of discrimination performance.

The generalization gradients obtained from each subject are shown in the right-hand portion of Fig. 1. In each case the peak of the gradient occurs at S+ (580 m μ). An earlier study (Terrace, 1964) showed that the peak of a gradient obtained after a shorter history on the same discrimination would have occurred at 590 m μ . Thus the peak shift, like behavioral contrast, is not a permanent characteristic of discrimination performance.

EXPERIMENT II

Method

This experiment was performed to trace the reversion of the peak of the post-discrimination gradients, at different stages of discrimination training, from its maximum point of displacement away from S—, back to S+. Except for two changes, the pre-discrimination and discrimination training procedures were the same as those followed in Exp I. The first change was the value of S—. Pilot experiments demonstrated that when the S+—S— difference was less than 20 m μ , a peak shift of 20 m μ resulted as compared with a 10-m μ shift that results when the S+—S— interval is larger. Since a 20-m μ peak shift could allow the displaced peak to shift back to S+ in two steps, the value of S— was changed from 540 to 560 m μ . The second change in procedure increased the number of generalization tests from one to four. These were given after the 15th, 30th, 45th, and 60th discrimination sessions.

Results

The four gradients obtained from each subject (G-346, G-352, G-339, G-355) are shown in Fig. 2. In each case the peak of the gradient was initially displaced 20 m μ away from S+; that is, the peak of the first gradient occurred at 600 m μ instead of at 580 m μ . During the next two generalization tests, each of the peaks shifted over to 590 m μ , and by the final generalization test, the peak had reverted back to S+ (580 m μ). Similar results have been obtained by the author from a different group of subjects for which the generalization tests were separated by 12 rather than 15 discrimination sessions (Terrace, 1966, p. 328ff), and by Pierrel and Sherman (1962) in an experiment concerned with auditory intensity discrimination in the white rat.

The pattern of the rate of responding to S+ in the discrimination sessions of Exp II was similar to that observed in Exp I. After discrimination training began, the rate of responding to S+ of each subject increased to at least twice the value of its pre-discrimination rate and then gradually reverted back to that value. Except for a slightly larger number of responses to S—, the pattern of S— responding in Exp II was similar to that in Exp I.

Fig. 1. Left-hand panel shows the rate of responding to S+ during pre-discrimination and discrimination sessions of each subject in the first experiment. Right-hand panel shows each subject's wavelength generalization gradient obtained following the 60th discrimination session.

DISCUSSION

Both experiments clearly demonstrated that behavioral contrast and the peak shift are not permanent characteristics of discrimination performance. Extended discrimination performance results in the gradual disappearance of both phenomena. These results are consistent with those of earlier experiments which indicate that behavioral contrast and the peak shift covary in the sense that the conditions

necessary to produce both seem identical and that one phenomenon is always accompanied by the other.

An analysis of the conditions necessary to produce these phenomena suggests that the emotional effects of response suppression play an important role in their genesis. As mentioned earlier, neither contrast nor the peak shift was observed following discrimination learning without errors. Responding to S- cannot be considered to have been suppressed

Fig. 2. Successive wavelength generalization gradients of individual subjects. The first test occurred after the 15th discrimination session; the remaining tests were each separated by 15 discrimination sessions.

in this instance because responding to S— never occurred (Terrace, 1963; 1964). In discrimination learning with errors, on the other hand, or in a discrimination between stimuli correlated with independent schedules in which responding to one stimulus was punished, or in a discrimination between stimuli correlated with VI and differential reinforcement of low rate schedules, behavioral contrast and the peak shift were reliably observed to occur (Terrace, 1965). Thus, the suppression of responding to one of two alternating discriminative stimuli, whether accomplished by non-reinforcement, punishment, or a reinforcement contingency which requires a low rate of responding, appears to be a sufficient condition for behavioral contrast and the peak shift to occur.²

Non-reinforcement and punishment have been shown in various experiments also to result in emotional effects. Azrin, Hutchinson, and McLaughlin (1965) and Azrin, Hutchinson, and Hake (1966), for example, have shown, in a wide variety of species, that unavoidable electric shock or extinction will produce aggressive behavior and that they will also make the opportunity to attack another organism or an inanimate object reinforcing. Skinner (1938) observed increased activity and fluctuations in response rate in the rat which he attributed to emotional responses. Amsel (1962) has attributed the increase in running speed following a non-reinforced trial in a runway to frustration. Finally, the present author has shown, in experiments on discrimination learning in the pigeon, that an S—, in

²It may prove worthwhile to determine whether the use of a correction procedure influences how long it takes for contrast to disappear. Bloomfield (1966) has noted that the type of contrast effect observed in this experiment, in which the rate of responding to S+ approaches a peak and then declines to a greater than

baseline value, seems to be specifically related to the correction procedure. When a correction procedure is not used during discrimination training, the rate of responding to S+ increases and then stabilizes at some asymptotic level.

the presence of which responding was extinguished, typically elicits agitated wing-flapping or turning away from S- (Terrace, 1966, p. 316ff).

The similarity of conditions which result in behavioral contrast and the peak shift, and conditions which result in emotional responses, point to the hypothesis that behavioral contrast and the peak shift are by-products of frustration, or similar emotional responses. Once these emotional responses have adapted out one would expect behavioral contrast and the peak shift to disappear. This account of behavioral contrast and the peak shift is supported by the present observation that both phenomena gradually disappear as a result of prolonged exposure to the discriminative stimuli.

REFERENCES

- Amsel, A. Frustrative nonreward in partial reinforcement and discrimination learning: Some recent history and theoretical extension. *Psychol. Rev.*, 1962, **69**, 306-328.
- Azrin, N. H., Hutchinson, R., and McLaughlin, R. The opportunity for aggression as an operant reinforcer during aversive stimulation. *J. exp. Anal. Behav.*, 1965, **8**, 171-180.
- Azrin, N. H., Hutchinson, R., and Hake, D. Extinction-induced aggression. *J. exp. Anal. Behav.*, 1966, **9**, 191-204.
- Bloomfield, T. M. Two types of behavioral contrast in discrimination learning. *J. exp. Anal. Behav.*, 1966, **9**, 155-161.
- Ferster, C. B. and Skinner, B. F. *Schedules of Reinforcement*. New York: Appleton-Century-Crofts, 1957.
- Hanson, H. M. Effects of discrimination training on stimulus generalization. *J. exp. Psychol.*, 1959, **58**, 321-334.
- Pierrel, Rosemary and Sherman, J. G. Generalization and discrimination as a function of the S^D - S^A intensity difference. *J. exp. Anal. Behav.*, 1962, **5**, 67-71.
- Reynolds, G. S. Behavioral contrast. *J. exp. Anal. Behav.*, 1961, **4**, 57-71.
- Skinner, B. F. *The Behavior of Organisms: An Experimental Analysis*. New York: Appleton-Century, 1938.
- Terrace, H. S. Discrimination training with and without "errors". *J. exp. Anal. Behav.*, 1963, **6**, 1-27.
- Terrace, H. S. Wavelength generalization after discrimination learning with and without errors. *Science*, 1964, **144**, 78-80.
- Terrace, H. S. Behavioral contrast and the peak shift. Paper read at Meetings of Psychonomic Society, 1965.
- Terrace, H. S. Stimulus control. In W. K. Honig (Ed.), *Operant Behavior: Areas of Research and Application*. New York: Appleton-Century-Crofts, 1966.

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