MAINTAINED GENERALIZATION TESTING OF CONDITIONED SUPPRESSION¹

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This study concerns the use of a multiple stimulus discrimination procedure for producing data on the generalization of conditioned suppression. Four rats were maintained on a variable interval schedule of milk reinforcement in the presence of five stimuli varying in auditory click rate. When response rates were stable, electric shock was regularly paired with the termination of one of the click stimuli. For two rats the shock was paired with the slowest click rate, and for two rats shock was paired with the fastest click rate. The VI schedule remained in effect. Plots of the relative rates of response to each of the five stimuli yielded concave gradients for both animals suppressed at the slowest click rate, and flat gradients with a sharp drop at the warning stimulus for both animals suppressed at the fastest click rate. When the warning stimuli were reversed for both pairs of subjects, both gradient forms were reproduced. The present procedure was contrasted with procedures used by other investigators.

One possible classification of the burgeoning literature on stimulus generalization would be on the basis of two general types of procedures. The older and more frequently used procedure follows the pioneering work of Guttman and Kalish (1956), and entails conditioning an organism until its behavior is stable with respect to a certain stimulus or stimuli (in the discrimination case) and then, in extinction, testing for generalization to a set of stimuli in a single session. A second method has been termed "maintained generalization testing" by Reynolds (1961) and, in different forms, utilized by Pierrel (1958), Pierrel and Sherman (1960), Honig (1961), and Honig and Slivka (1964). The distinguishing feature of this class of procedures is that all stimuli for which the generalization function is to be measured are presented throughout most, if not all, of the experiment, usually with different contingencies in effect between those stimuli which would be classed as training and testing stimuli by the first procedure. Operationally, it is perhaps safer to call this method simply "multiple discrimination

training" as Pierrel and Sherman (1960) imply. However, all of the above investigators clearly feel that they are dealing with phenomena involving a "spread of effect" and thus use the term generalization.

Using this maintained generalization testing procedure, Honig (1961) and Reynolds (1961) have investigated the effects of extinction in the presence of specific stimuli, and Honig and Slivka (1964) have looked at punishment effects. This procedure seems particularly suited for the study of gradients of response decrement, as Honig has pointed out. A baseline of response rates can be achieved through multiple stimulus training, and then the aversive stimulus correlated with a particular stimulus and changes in rate to all stimuli assessed. Such a procedure, in outline, was used in the present investigation in the case where one stimulus is paired with an electric shock not contingent on behavior: the conditioned suppression or CER paradigm originally studied by Estes and Skinner (1941). This procedure has the advantage of making generalization data available at any period after the introduction of the aversive stimulus. Data presently available on the generalization of conditioned suppression (Ray and Stein, 1959; Hoffman and Fleshler, 1961; Desiderato, 1964) were obtained after a suppression criterion was met and may have missed generalization effects of significance occurring during the early stages of the procedure.

¹This investigation was supported in part by Public Health Service Research Grants MH-05875 and HD-00933-03, from the National Institute of Mental Health and by a grant from the Eugene Higgins Fund. The assistance of Perrin S. Cohen and Henry S. Ludlam in conducting the experiment is gratefully acknowledged. Reprints may be obtained from the author, Dept. of Psychology, Columbia University, 358A Schermerhorn Hall, New York 27, N. Y.

METHOD

Subjects and Apparatus

Four naive male albino rats, approximately 120 days old at the start of the experiment, were maintained at 80% of their free-feeding weights. An unlit operant conditioning chamber, 13 by 10½ by 14 in., contained a pedal lever requiring a force of 15 g mounted in the front wall, and a dipper in the rear wall. Seven large floor grids, described by Dinsmoor (1958), served as shock electrodes. The walls of the chamber, of stainless steel, served as an eighth electrode. The lever was not electrified. The dipper delivered 0.01 cc of Borden's Eagle Brand condensed milk mixed in a 50% solution, by volume, with tap water. The chamber was enclosed in a Scientific Prototype Model SPC-300 sound attenuating chamber.

A Foringer Model 1293 click generator provided auditory clicks varying in repetition rate (pps). The over-all noise level in the outer chamber with the blower on, as measured with a Model 1551B General Radio sound level meter calibrated to a 400 cps tone at 2 v, was between 97 and 98 db re 0.0002 microbar and did not vary with changes in click rate. The shock source was a Grason-Stadler Model 1064 shock generator and scrambler set to deliver a 0.5 sec shock of 1.0 milliampere. Experimental contingencies and recording were automatically controlled by a system of relays, timers, and counters.

Procedure

Each of five click stimuli (0.62 pps, 1.7 pps, 4.8 pps, 10.9 pps, 26.7 pps) was presented for a 2½-min period eight times in a random sequence during every 100-min daily session throughout the experiment. Two sessions were devoted to shaping the bar press and to regular reinforcement. Thereafter, a VI schedule of reinforcement with a mean of 1.2 min (VI 1.2) was in effect. After 18 sessions of VI training, the aversive stimulus was introduced according to the conditioned suppression paradigm. Each time the stimulus designated as the warning stimulus (S^w) for that S was presented, it terminated simultaneously with the shock. Each S thus received eight shocks during each session. For two S s, R28 and R29, the warning stimulus was 0.62 pps; for the other two, R30 and R31, S^w was 26.7 pps. After 32 sessions of suppression training, S^w was shifted

for all S s, shock now being paired with 26.7 pps instead of 0.62 pps for R28 and R29, and with 0.62 pps instead of 26.7 pps for R30 and R31. This phase of the experiment lasted 50 sessions for R28 and R29, 47 sessions for R30, and 45 sessions for R31. Again, for all sessions of the experiment, the varying clicker schedule and the VI schedule of milk reinforcement remained in effect. Only the shock presentations were varied.

RESULTS

The data are summarized in Fig. 1 in the form of relative gradients by three day periods. The total number of responses for a given three day gradient is indicated by the number underneath the gradient for that period. On the basis of the psychophysical data of Mostofsky, Shurtleff, and Margolius (in press), it seems that a logarithmic scale comes closest to reflecting the rat's discriminative capacity for click rate.

The first row of Fig. 1 shows the flat gradients obtained from Sessions 16-18, the last three sessions before the introduction of shock. It can be seen that the rate of response was essentially constant for all stimuli. The second, third, and fourth rows show gradients based upon the first three, middle three, and last three sessions after the introduction of shock to 0.62 pps for R28 and R29 (indicated by the arrows labeled S^w) and 26.7 pps for R30 and R31. The terminal gradients of row 4 from this procedure differ markedly according to which stimulus was paired with shock; the gradients from the two S s for which S^w was the slowest click rate are concave-upwards in shape, while the other two gradients are rather flat with a sharp drop at 26.7 pps.

A day-by-day examination of the gradients shows that the initial effect of the introduction of the suppression procedure was a large over-all decrease in rate, with the rate of recovery in each stimulus proportional to the distance of the stimulus from S^w for R28 and R29, and rather constant for all stimuli but S^w in the case of R30 and R31. The over-all rate, as indicated by the total number of responses in Fig. 1, is still lower after 32 sessions of suppression training for R28 and R29 (row 4) than it was during the last three sessions before suppression training (row 1). The consistent disparity between the two pairs of S s is shown

Fig. 1. Relative gradients by three-session blocks for four rats. The total number of responses on which each gradient is based is indicated under each gradient. Sessions are indicated under Rat 28 and row numbers are in the right-hand margin. Arrows indicate the warning stimulus.

again by the over-all increase in rate for R30 and R31 (compare row 4 totals with row 1).

The similarity of the gradients for each pair and the differences between the pairs led to the switching of the warning stimuli after session 51. The data from this procedure are shown in alternate blocks of three sessions through the first 24 sessions in rows 5-8 and then, as a check on stability after approximately 25 sessions more, in the final session in row 9. The terminal gradients from row 9 may be compared with the terminal gradients from row 4 with interesting results. The concave-upward gradients of R28 and R29 are seen to have become quite similar to those of R30 and R31 in row 4, while the gradients of R30 and R31 have become more concave-upward in shape. Evidently, the multiple discrimination procedure employed in this study produced gradients which are replicable and reversible. The slight inversion from 10.9 pps to 26.7 pps found for R29 in row 4 shows up here for both R30 and R31.

The course of the transition from one type of gradient to the other shows some provocative effects. In rows 5 and 6 the modes of all four gradients appear at intermediate stimuli and this phenomenon persists for R28 and R29 for a longer time, never disappearing for R29.

DISCUSSION

It is apparent that the shapes of the gradients obtained are not independent of whether the warning stimulus is at the slowest or the fastest repetition rate. One interpretation commonly found in the literature for such phenomena, based on Hull's (1951) analysis of Hovland's (1937) data, is in terms of "stimulus intensity dynamism"; i.e., the greater the stimulus intensity, the stronger the response. Stevens and Shickman (1959) have presented data based on psychophysical scaling procedures indicating that apparent click rate should be considered as an intensive, or prothetic, dimension. The present data require an additional statement to explain the lack of any dynamism-like effect before introduction of shock. It may be that click rate is an irrelevant dimension to the rat before any differential treatment is associated with some aspect of the stimulus. This argument has been raised by Jenkins and Harrison (1960) to account for

the flat generalization gradients they obtained from pigeons to pure tone stimuli prior to discrimination training. If a dynamism effect which increases linearly with log click rate is assumed, from which generalization decrements proportional to distance from S^w are subtracted, the observed gradients in rows 4 and 9 may be closely approximated. Of course, whatever adequacy this account may possess is limited by its *post hoc* and hypothetical qualities. In addition, it should be noted that neither Pierrel (1958), with rats as subjects and intensity of a pure tone as the stimulus dimension, nor Blough (1959), with pigeons and brightness of a red key, found any evidence of stimulus intensity dynamism in their generalization data. The Pierrel study used a multiple discrimination procedure with many similarities to the method employed in this study.

The small but persistent inversions of the gradients between 10.9 pps and 26.7 pps evident in row 4 for R29 and row 9 for R30 and R31, cannot be ascribed to an inability to discriminate the two stimuli, as the difference in rates between these two stimuli is considerable when 26.7 pps is the warning stimulus. The inversions are possibly an artifact of the stimulus sequences used which, while randomized, were unfortunately not free of sequential biases.

Methodological differences make any comparisons between the present data and the small literature on the generalization of conditioned suppression limited. Three major differences to be pointed out are: (a) the cessation of the pairing of shock with S^w during the generalization testing period in the other studies (Hoffman and Fleshler, 1961; Ray and Stein, 1959; Desiderato, 1964); (b) the lack of a silent period preceding S^w in the present investigation; and (c) the use of a suppression ratio as the dependent variable in the plot of the gradient in the earlier studies. In general, however, one may point to the gradual sharpening of suppression to S^w as conforming to the findings of Hoffman and Fleshler (1961) and Desiderato (1964). The present procedure seems to offer some advantages over those procedures which separate training and testing in that extinction effects during testing are minimized and the entire duration of the experiment is available to study generalization effects. In effect, a "steady state" generaliza-

tion gradient can be attained. Complex processes, such as the simultaneous extinction of suppression to one stimulus and institution of suppression to another stimulus, as in rows 5-9, Fig. 1, may be studied in combination. The present study, it should be pointed out, yields only suggestive data on this problem, failing as it does to provide data on extinction of suppression alone.

REFERENCES

- Blough, D. Generalization and preference on a stimulus intensity continuum. *J. exp. Anal. Behav.*, 1959, 2, 307-317.
- Desiderato, O. Generalization of conditioned suppression. *J. comp. physiol. Psychol.*, 1964, 57, 434-437.
- Dinsmoor, J. A. A new shock grid for rats. *J. exp. Anal. Behav.*, 1958, 1, 264.
- Estes, W. K. and Skinner, B. F. Some quantitative properties of anxiety. *J. exp. Psychol.*, 1941, 29, 390-400.
- Guttman, N. and Kalish, H. I. Discriminability and stimulus generalization. *J. exp. Psychol.*, 1956, 51, 79-88.
- Hoffman, H. S. and Fleshler, M. Stimulus factors in aversive controls: the generalization of conditioned suppression. *J. exp. Anal. Behav.*, 1961, 4, 371-378.
- Honig, W. K. Generalization of extinction on the spectral continuum. *Psychol. Rec.*, 1961, 11, 269-278.
- Honig, W. K. and Slivka, R. M. Stimulus generalization of the effects of punishment. *J. exp. Anal. Behav.*, 1964, 7, 21-25.
- Hovland, C. I. The generalization of conditioned responses: II. The sensory generalization of conditioned responses with varying intensities of tone. *J. Genet. Psychol.*, 1937, 51, 279-291.
- Hull, C. L. *Essentials of Behavior*. New Haven: Yale University Press, 1951.
- Jenkins, H. M. and Harrison, R. H. Effect of discrimination training on auditory generalization. *J. exp. Psychol.*, 1960, 59, 246-253.
- Mostofsky, D. I., Shurtleff, D. A., and Margolius, G. The comparative sensitivity of rats and humans to changes in auditory click rate. *J. comp. physiol. Psychol.*, in press.
- Pierrel, R. A generalization gradient for auditory intensity in the rat. *J. exp. Anal. Behav.*, 1958, 1, 303-313.
- Pierrel, R. and Sherman, J. G. Generalization of auditory intensity following discrimination training. *J. exp. Anal. Behav.*, 1960, 3, 313-322.
- Ray, O. S. and Stein, L. Generalization of conditioned suppression. *J. exp. Anal. Behav.*, 1959, 2, 357-361.
- Reynolds, G. S. Contrast, generalization, and the process of discrimination. *J. exp. Anal. Behav.*, 1961, 4, 289-294.
- Stevens, J. C. and Shickman, G. M. The perception of repetition rate. *J. exp. Psychol.*, 1959, 58, 433-440.

Received July 27, 1964