

## STIMULUS GENERALIZATION OF THE EFFECTS OF PUNISHMENT<sup>1</sup>

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Three pigeons were trained to respond to seven spectral stimulus values ranging from 490 to 610  $m\mu$  and displayed in random order on a response key. After response rates had equalized to these values, a brief electric shock was administered when the subject (S) responded to the central value (550  $m\mu$ ) while positive reinforcement for all values was maintained. Initially, there was broad generalization of the resulting depression in response rate, but the gradients grew steeper in the course of testing. When punishment was discontinued, the rates to all values recovered, and equal responding to all stimuli was reattained by two of the Ss. Stimulus control over the effects of punishment was clearly demonstrated in the form of a generalization gradient; this probably resulted from the combined effects of generalization of the depression associated with punishment and discrimination between the punished value and neutral stimuli.

This study sought to explore stimulus control over the effects of punishment by obtaining generalization gradients for the decrement in response rate induced by response-contingent shocks. The general procedure was similar in many ways to the methods which have yielded reliable generalization gradients following acquisition with positive reinforcement (*e.g.*, Guttman and Kalish, 1956). Gradients of response decrement are inverted with respect to the usual gradients of response strength. The effect of punishment on responding to any given stimulus value must be assessed against a baseline of response rates obtained prior to punishment from a number of stimuli lying on the continuum. Gradients of response decrement have been obtained by a similar method around a stimulus associated with extinction (Honig, 1961). With different techniques, other gradients of decrement have been studied for the negative stimulus used in discrimination training (Honig, Boneau, Burstein, and Pennypacker, 1963; Jenkins and Harrison, 1962) and for a stimulus used in association with an unavoidable shock to develop a conditioned suppression (Hoffman and Fleshler, 1961).

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Discriminative stimulus control over punishment effects has been shown in operant situations by Azrin (1956) and Dinsmoor (1952). In Azrin's study, pigeons were used, and responding in the presence of an orange stimulus light was markedly depressed when this light signalled periods in which a response-contingent shock was scheduled; this was readily discriminated from a blue light projected on the response key during safe periods. Dinsmoor used rats which learned to discriminate safe periods correlated with onset of a light which illuminated the animal's chamber, from punishment periods in the dark. Neither of these experimenters attempted to obtain generalization gradients from stimulus values lying between those used in discrimination training. But their demonstrations of discriminative control, together with the variety of generalization gradients which have been generated in operant situations after various kinds of training, led us to expect that orderly punishment gradients could be obtained.

### METHOD

#### *Subjects*

Three fully-grown White King pigeons were used throughout the study at 75% of their free-feeding weight. They had been rejected from another study in which they were reinforced for standing still, a task for which they demonstrated little aptitude.

### Apparatus

A two-key operant behavior box was used; it is described elsewhere (Honig, 1962). Spectral values were produced by passing white light through Bausch and Lomb monochromatic interference filters and projecting it on the key. A yellow (Wratten K-2) filter was inserted in the beam with values greater than  $570\text{ m}\mu$  to eliminate the visible second-order spectrum. Only the right key of the apparatus was used for the present research.

The method of administering shock was adapted from Hoffman (1960). Chrome-plated bead chain of 0.156 in. diameter was wrapped twice around the base of each wing. The down under the wing was plucked to insure good contact between the bead chain and the skin. A flexible connector could be attached to each chain by a pair of Muller test clips. The shock was provided by a variable transformer ("Variac") at a setting of 50 v, and with a 50,000 ohm resistance in series with the bird, about 0.75 ma were delivered. The shock duration was 0.6 sec.

### Procedure

Preliminary training was carried out in successive sessions as follows. First, *S* was allowed to eat from the open food magazine for 3 min. Second, *S* was trained to eat during the 4-sec magazine cycle. Third, *S* was taught by successive approximations to peck at the key illuminated by  $550\text{ m}\mu$  and was given 50 continuous reinforcements immediately following conditioning. Fourth, *S* received 10 continuous reinforcements with each of the seven stimulus values displayed on the key in randomized order. On the fifth day, *S* was reinforced five times on a FR 5 schedule for pecking at each of the stimulus values displayed in a random order, and this procedure was repeated with a FR 10 schedule.

During the VI training, punishment, and recovery phases of the study, seven stimulus values ranging in  $20\text{ m}\mu$  steps from 490 to  $610\text{ m}\mu$  were employed. Each training session consisted of 28 periods of 1 min each of stimulus presentation followed by 10 sec of blackout. The seven stimulus values were each presented four times, once in each of four randomized blocks.

A VI 30-sec schedule programmed reinforcement for training sessions 1-6; this was

changed to VI 75 sec for sessions 7-19; from session 20 to the end of the study, the mean inter-reinforcement interval was reduced to 37.5 sec, since rates did not stabilize well under the VI 75-sec program. As extinction of positive reinforcement was not used during this study, a relatively short VI interval did not detract from efforts to obtain generalization gradients.

Wing bands were attached after 16 training sessions, and from session 25 on, the clips were fastened to the bands at the start of each session. The birds could move freely about the box, and the attachment had no noticeable effect on response rate.

Beginning with session 31, punishment was automatically administered for nine sessions whenever *S* responded to the  $550\text{ m}\mu$  stimulus (but not for responses to other stimuli). Reinforcements were scheduled as before for all stimulus values. Beginning with session 40, punishment was discontinued for nine sessions in order to observe the recovery of response rate. All other conditions remained the same.

## RESULTS

The combined results are presented for the three *Ss* in Fig. 1 and 2 in terms of mean response rates per minute. In each figure, the VI baseline is based on the mean rates for the last six days of training preceding the introduction of punishment. Under this condition the rates are quite similar for the seven stimulus values. In Fig. 1, both the effects of punishment at  $550\text{ m}\mu$  and the generalization of response decrement to other values is shown for three blocks of three sessions each. Responding to  $550\text{ m}\mu$  dropped to zero as soon as punishment was introduced. While the other values were also affected, a progressive increase in rate can be seen both as a function of the difference between  $550\text{ m}\mu$  and the other stimuli, and as a function of time, since the response rates increased during the three successive blocks. Recovery data are similarly presented in Fig. 2. Rates to  $550\text{ m}\mu$  and adjacent values recover fastest, flattening the gradient. For the last three sessions, recovery is almost complete; the terminal gradient is close to the VI baseline save for a small depression remaining at  $550\text{ m}\mu$ .

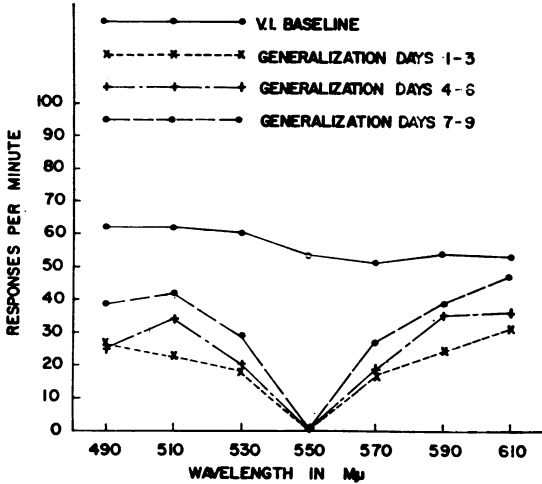


Fig. 1. Mean response rates obtained for different values during nine sessions while punishment was in effect at 550 mμ.

Results for the three Ss are individually presented in Fig. 3. The VI baseline is presented for each bird, together with mean rates obtained for the nine sessions of punishment and the nine sessions of recovery. Each S shows a different individual pattern of stimulus control. For S1, the punishment gradient is very steep and attains the level of the VI baseline at both ends. The recovery gradient is almost parallel to the punishment gradient, except that it is displaced upward so that some of it is below and some of it is above the VI baseline. For S2, the punishment gradient is much flatter and the recovery gradient is almost identical to the VI baseline. For S3, a

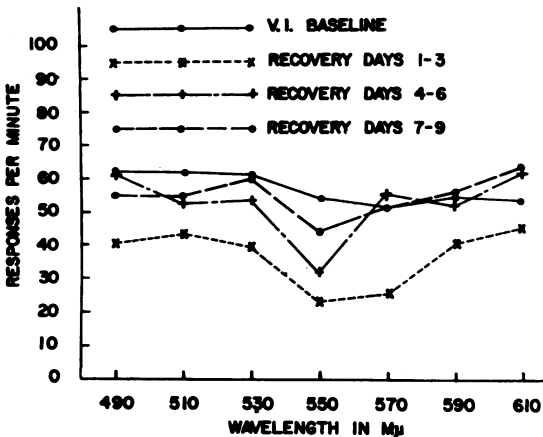


Fig. 2. Mean response rates obtained for different stimulus values during nine sessions after punishment at 550 mμ was discontinued.

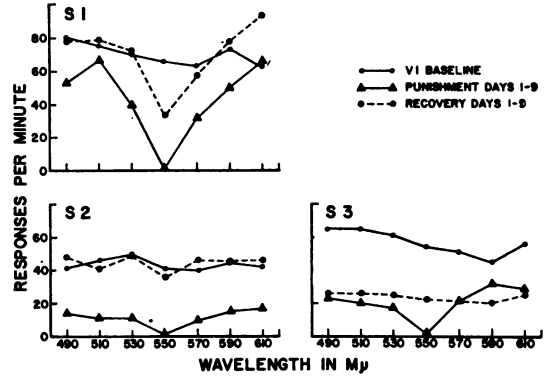


Fig. 3. Mean response rates obtained from the three individual Ss during the last six sessions of VI training, nine sessions of punishment, and nine sessions of recovery.

third pattern appears; the punishment gradient is intermediate in slope to those of the other two, and, while the recovery gradient is quite flat, it remains well below the overall level of responding indicated by the VI baseline. The general form of all punishment gradients is concave downward for all birds, although the slopes differ. But the recovery gradients are very different both in form and overall response level, and the similarity of the mean recovery gradient to the VI baseline (see Fig. 2) may be a coincidence due to averaging across Ss.

A temporal analysis of the effect of punishment is presented in Fig. 4. Here, the mean response rates are presented for the three 1-min periods immediately preceding and immediately following each punishment period as averaged across the various spectral values presented in these periods.<sup>2</sup> These data are presented for three blocks of three punishment sessions each. In the 3 min preceding each period of punishment, response rates are about equal. Following each period of punishment, the rates are depressed. This is most marked for sessions 1-3 where the depression extends to the 3 min following punishment, but recovery is increasingly rapid for days 4-6 and 7-9. For the latter two blocks, the rates during the second and third

<sup>2</sup>Due to the random order of stimuli, two punishment periods could be close together, so that the periods immediately following one would overlap those immediately preceding the next. For this reason, only those punishment periods were used in this analysis which were separated from the preceding and succeeding punishment periods by at least 4 min.

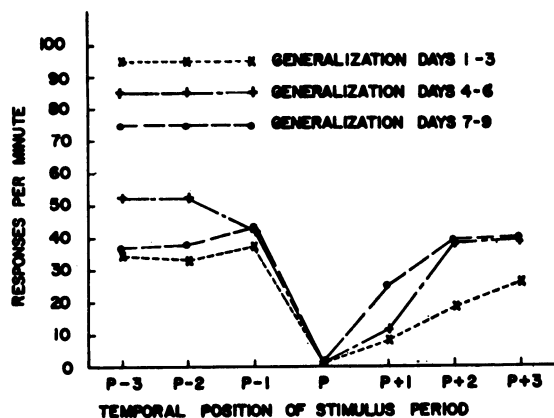


Fig. 4. Mean response rates obtained for the stimulus periods immediately preceding and following each punishment period (P).

minutes following punishment are equal to the rates preceding punishment. It is likely that if the punishment procedure had continued, the rate for the first period following punishment would have recovered to an equal extent.

## DISCUSSION

From these analyses, it appears that during any given stage of the generalization-punishment procedure, two major variables affected the rate of responding: (1) the difference between a given stimulus value and 550  $m\mu$  (stimulus effect), and (2) the interval between the presentation of that value and the preceding punishment period (temporal effect). These two effects were randomly combined in that neither stimulus value nor punishment-stimulus interval was held constant while the other was varied; since the stimulus values were randomized, the rates obtained for each temporal interval reflect the temporal effect in combination with the mean of the set of stimulus effects produced by the different values.

Initially, neither of these effects was great enough to eliminate the depression of rate due to punishment, since the generalization and temporal gradients do not approach the VI baseline. But both effects change systematically in the course of punishment. The stimulus effect becomes more pronounced, in that response rates to values other than 550  $m\mu$  increase; in other words, the Ss appeared to be developing a stimulus discrimination.

The temporal effect becomes less important as stimulus control increases; by the end of the punishment sequence, this effect extended only to the period directly following punishment. It is unlikely that the temporal effect decreased in importance because Ss were receiving fewer actual shocks during punishment periods in the course of the punishment sequence; each response was punished, and the response rate to 550  $m\mu$  was close to zero during the whole time that punishment was in effect. The shift in control over response rate from a temporal to a stimulus basis is therefore genuine and reflects a process of stimulus discrimination. A similar steepening can be obtained for positive generalization gradients if the reinforced value is embedded between two or more stimuli in the presence of which reinforcement is not available (Hanson, 1961).

It is of particular interest to compare the present results with those of Hoffman and Fleshler (1961), since these experimenters also used a noxious stimulus to induce a response decrement. They presented a 1,000-cycle tone in advance of an unavoidable shock of 8-sec duration. After complete suppression of responding in the presence of this stimulus, shocks were discontinued while test tones ranging from 300 to 3,400 cycles were presented. At first, generalization of suppression was almost complete for all the test tones, but the rate of recovery was directly related to the differences between each test tone and the 1,000-cycle training tone, yielding orderly gradients of response decrement. Their gradients, therefore, reflect different rates of extinction of the suppression in the presence of different test values. Our gradients also grew steeper in the course of testing, but this may have been due to the opportunity for explicit discrimination learning provided by the fact that in the presence of one stimulus, punishment was maintained during the testing procedure. When punishment was discontinued, the gradients grew flatter, at least for two Ss, as the decrement extinguished at 550  $m\mu$  and adjacent stimuli. A similar result was obtained by Hoffman, Fleshler, and Jensen (1962) in a continuation of the earlier study, where the birds were retested after two and one half years away from the experimental situation.

Clearly, the design of the conditioned suppression and the punishment studies should

be made more similar to determine whether the obtained similarities in results are genuine or fortuitous. It remains to be seen whether the steepening of the punishment gradient would be obtained where explicit discrimination training is not provided. Once a baseline is established, this can be done by punishing responding to 550  $m\mu$  without the presentation of the other values used to establish the VI baseline. Then the complete set of stimuli would be reintroduced after punishment is discontinued. Attention is now being given to this problem.

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