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THE ROLE OF DISCRIMINATION TRAINING IN THE GENERALIZATION OF PUNISHMENT[1]

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Pigeons were trained to respond equally to various orientations of three parallel lines projected on a response key. One group was then punished for responding to the vertical lines, but not punished in a line-absent condition. Two other groups were also punished but had no opportunity to make such a discrimination. Orderly generalization gradients were obtained from the discrimination group during recovery from punishment, with least responding to the vertical lines and higher rates to other orientations. Gradients obtained from the non-discrimination groups were flat. A discrimination of punishment contingencies appears to be necessary for a stimulus correlated with punishment to acquire control over its reductive effects.

Previous studies of the generalization of punishment (Hoffman and Fleshler, 1965; Honig and Slivka, 1964) have obtained gradients in which response rates increased as a function of the difference between a stimulus correlated with a punishment contingency and other stimuli not paired with punishment. In each case, generalization tests followed or accompanied the opportunity to discriminate the "warning" stimulus correlated with punishment from one or more "safe" stimuli. Hoffman and Fleshler (1965) compared punishment and conditioned suppression, and a warning tone always accompanied the contingency in which responses would be followed by electric shock, while the absence of the tone was correlated with the absence of shocks. A gradient was obtained in a test carried out after punishment was discontinued, although recovery of responding was rapid. Honig and Slivka first obtained a "baseline" of equal responding to a number of spectral values ranging from 490 to 610 mμ. Punishment was then introduced when one of these values (550 mμ) was displayed, in alternation with the remaining baseline stimuli. This multiple discrimination procedure resulted in gradients which increased in slope in the course of testing. After punishment was discontinued, orderly decremental gradients were obtained for a time around the warning stimulus before the baseline pattern of equal responding to all stimuli was reattained.

From these studies it cannot be ascertained whether the opportunity to discriminate a warning stimulus from one or more safe conditions is necessary for the stimulus to gain control over the decrement in rate of a punished response, or whether a simple association of punishment with a given warning stimulus is sufficient. A preliminary study by Slivka and Honig (1964) indicated that the latter is insufficient. After baseline training modeled on their previous study, they punished two pigeons for responding to 550 mμ which was presented in alternation with blackout periods rather than other wavelength values. Testing in recovery, they obtained no gradient of punishment, and very rapid reattainment of the variable interval baseline response level.

The present experiment represents a more systematic attempt to investigate this problem. The "safe" stimulus (absence of a pattern of lines) was orthogonal to the dimension (line orientation) on which generalization gradients were obtained. Testing was carried out in recovery, so that the testing procedure could not provide an opportunity for a punishment discrimination to develop.

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METHOD

Subjects

Ten fully grown domestic pigeons, crossbred between Homers and Modenas, were maintained at about 75% of free-feeding weight.

Apparatus

Two automatic Grason-Stadler pigeon boxes were used, with associated programming and recording equipment. The key in each box was illuminated by an in-line digital display projector. The stimuli consisted of three parallel black lines upon a circular white background. The individual lines were about 1/8 in. wide. These parallel lines could be presented in eight different orientations: horizontal, arbitrarily called 0°, at inclinations of 22½°, 45°, *etc.* A ninth stimulus condition was provided by the white background without any black lines. The key illumination provided the only light in the box, except during reinforcements, when the magazine light was on.

The birds were shocked through wing bands made of bead chain and attached to a flexible connector, in the manner described by Hoffman (1960). The down was plucked at the base of each wing to ensure good contact with the skin. Each shock was ½ sec in duration with an amplitude of 0.5 ma ac.

Procedure

After magazine training, all birds were trained to peck at the white, no-line stimulus, and then provided with 50 continuous reinforcements during each of two sessions. This was followed by two sessions of adaptation to a variable interval (VI) schedule with a mean inter-reinforcement time of 20 sec. Each session terminated when 40 reinforcements were received. Each reinforcement consisted of presenting grain for 5 sec.

Variable interval baseline training was then begun. This was designed to provide equal training with the stimuli on the dimension of angular orientation, in order to obtain the "baseline" necessary to assess the effects of punishment. Each session consisted of three blocks of nine stimulus periods. Each of the eight orientations and the no-line stimulus were presented once during a block, in random order. A VI 37½-sec schedule was in effect during all periods. Each stimulus period was 60 sec long, followed by 5 sec of blackout. During at least the last six sessions of VI training, the flexible connector used to deliver shocks was attached to the wing bands of each bird. This had no discernible effect on response rate.

After 30 sessions of VI training, all animals received 10 sessions of training with punishment. Each punishment session consisted of 24 1-min periods divided into six blocks of four trials. One trial from each block was randomly selected for punishment, when all responses were followed by a ½-sec shock. For all three groups, vertical lines (the 90° stimulus) were presented on the response key during these periods as the warning stimulus. The groups differed only with respect to the stimuli displayed during the remaining three trials of each block, when punishment was not administered ("safe periods"). For the *discrimination group* (four birds), the no-line white key was presented. For the *no-discrimination group* (three birds), the three vertical lines were presented during the safe periods as well as the punishment periods. For the *blank-trials group* (three birds), the key and the experimental chamber remained dark during the safe periods. All groups, therefore, had the same distribution of punishment periods, but only the discrimination group had the opportunity to develop a discrimination between a stimulus correlated with punishment and a safe stimulus. The no-discrimination group received punishment with the same degree of intermittency as the discrimination group. For the blank-trials group, punishment was presented on a continuous schedule, since the birds did not respond in the dark box. The VI schedule of positive reinforcement was in effect during all sessions of this phase of training.

Three recovery sessions were presented after the punishment sessions to provide generalization data. These sessions were identical to those used to obtain the VI baseline.

RESULTS

The mean response rates during the last four days of punishment training are presented for individual subjects in Table 1. The discrimination procedure was clearly effective, with a high rate of responding during

Table 1

Mean Response Rates During the Last Four Punishment Sessions

Discrimination Group	*Punishment Periods*	*Safe Periods*
S 50	0.3	71.9
S 55	0.4	46.0
S 61	0.0	62.1
S 65	0.0	98.7
Mean	0.2	69.7
No-Discrimination Group		
S 49	0.2	1.1
S 53	4.5	21.4
S 67	0.5	4.6
Mean	1.7	9.0
Blank-Trials Group		
S 62	0.0	
S 64	1.1	
S 66	6.2	
Mean	2.4	

the safe periods, and negligible responding during punishment periods. The discrimination performance appeared to be under the control of the displayed stimuli. The daily records show that during many of the punishment periods, the subjects made no responses; in other words, they were not using the occurrence of one or two shocks at the beginning of a punishment period as a cue to cease responding during the remainder of the period. For the subjects in the no-discrimination group, response rate during the safe periods was much lower, and during the punishment periods somewhat higher than corresponding rates in the discrimination group. The latter difference is due largely to the results of one subject. It would appear, therefore (and this is hardly surprising), that there was a good deal of generalization between the punished and safe conditions in this group. The difference in rate between these two conditions may have been due either to the dissipation during safe periods of the depressing effects of shocks received in the punishment periods, or to a discrimination based upon the occurrence of shocks which could indicate to the subject that the response-shock contingency would be in effect during the remainder of the period, or to both of these processes. The response rate for the blank-trials group was on the whole rather low, and again demonstrates the depressing effects of the punishment.

The data from the three recovery sessions are shown in Fig. 1 for the discrimination group. The VI baseline is based upon the response rates obtained during five of the last six sessions of training before punishment was introduced.[2] This baseline is rather flat; the mean rates range from 63 to 71 responses per min. During the first day of recovery, on the other hand, there is a sharp reduction at and around the punished stimulus of 90°. The ends of the gradient "over-shoot" the VI baseline and approach the rate obtained for the safe stimulus. During the second recovery session, a shallow but orderly gradient around 90° can still be seen. During the third day, there is only the merest suggestion of a depression in response rate about 90° and all rates exceed the VI baseline. The response rate to the no-line stimulus, which exceeds the rate to any of the line stimuli at the beginning of recovery, approaches the mean rate to the line stimuli as recovery proceeds. During the second session the mean rate for the line stimuli is 68.5, while that for the no-line stimulus is 71; during the third session, the corresponding values are 77.5 and 76.

The recovery data from the no-discrimination group are shown in Fig. 2. All curves are roughly parallel, and there is no indication of a generalization gradient. Mean response rates for all stimuli are lower on the first day of recovery (42.1 responses/min) than on the VI baseline (47.3 responses/min). The rates increase during recovery training, with mean rates of 43.1 and 44.7 on the second and third sessions. During the last session, the recovery "gradient" exceeds the VI baseline at three points, but there is no consistent enhancement of rate over the baseline level.

The recovery data for the blank-trials group are distinguished by the fact that only one of three subjects (*S* 64) responded during the first session. It was joined by a second subject (*S* 66) during the second session, but the third one (*S* 62, which had the lowest rate during the punishment procedure) did not start responding until after the third session began, and then responded rather erratically. If all

[2]For a few birds, data were unavailable from one of the last five days of VI training, usually because the print-out counter had not recorded properly. Data used for the VI baseline were taken from the last five sessions in which responses were properly recorded.

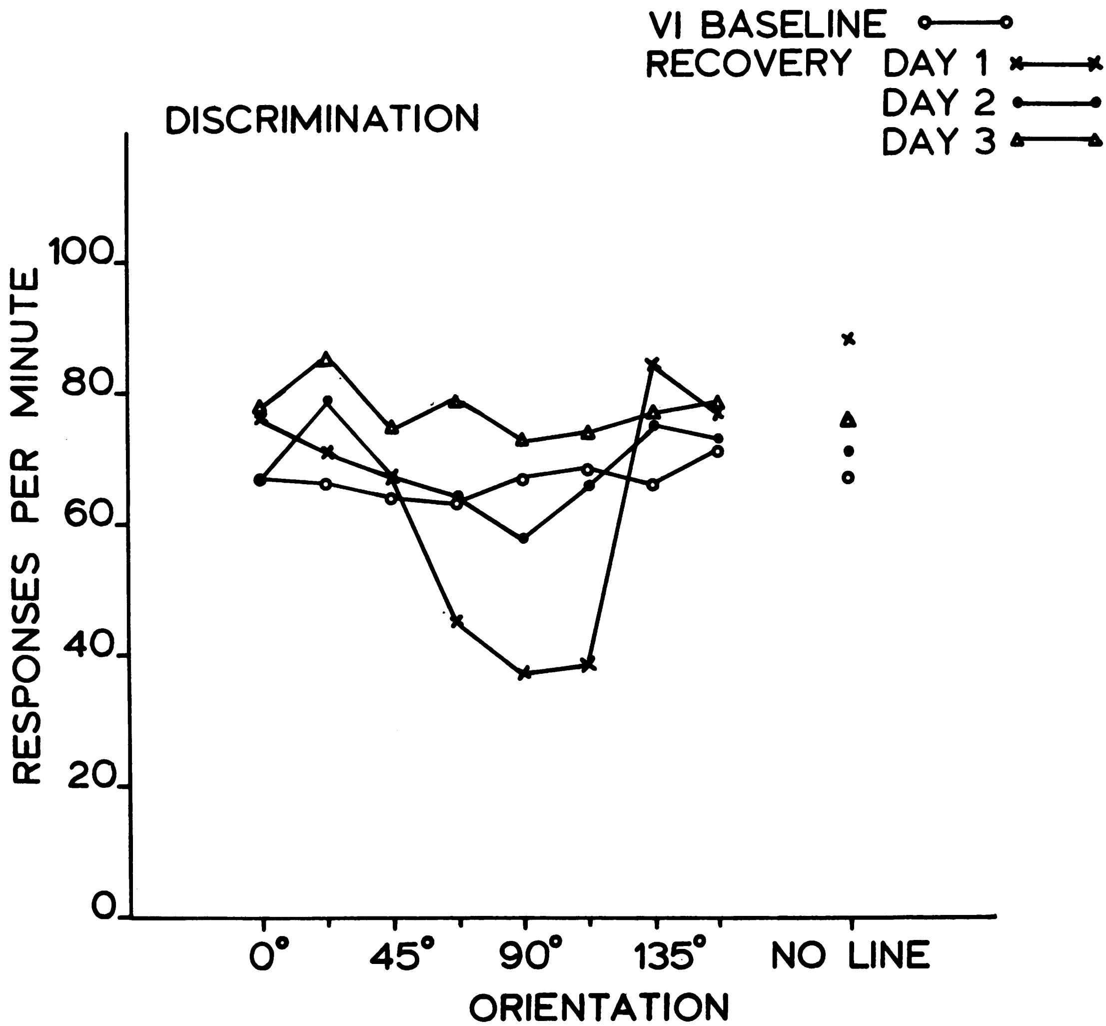

Fig. 1. Response rates obtained from the discrimination group at the end of VI training (VI baseline) and during three recovery sessions following punishment.

data from all subjects were included in the curves on Fig. 3, it would give the misleading impression of a gradual recovery in the course of the three sessions, rather than the rapid recovery actually observed when an animal began to respond. The mean rates presented in that figure therefore reflect the data only from those subjects actually responding during a session, but include all data obtained from them for a given session. It is apparent from this method of presentation that recovery is almost immediate when the subject starts to respond. Rates generally exceed the VI baseline except during the third session, where the mean rate is reduced, since *S* 62, the animal that recovered last, did not respond or worked at a very low rate during a number of periods.

With this method of presenting the results of the blank-trials group, different days of actual recovery (as indicated by the initiation of responding) are combined in each curve except for Session 1, where only *S* 64 is represented. It is possible that recovery gradients obtained during initial recovery from the other two subjects are obscured by data from the bird or birds that recovered earlier. The response rates per minute from the first day of *actual* recovery have therefore been averaged and are also shown in Fig. 3. Periods in which no responses were emitted were excluded from this particular analysis, since the data suggested that, for this group, recovery was an "all-or-nothing" phenomenon. While this form of analysis does demonstrate a slight de-

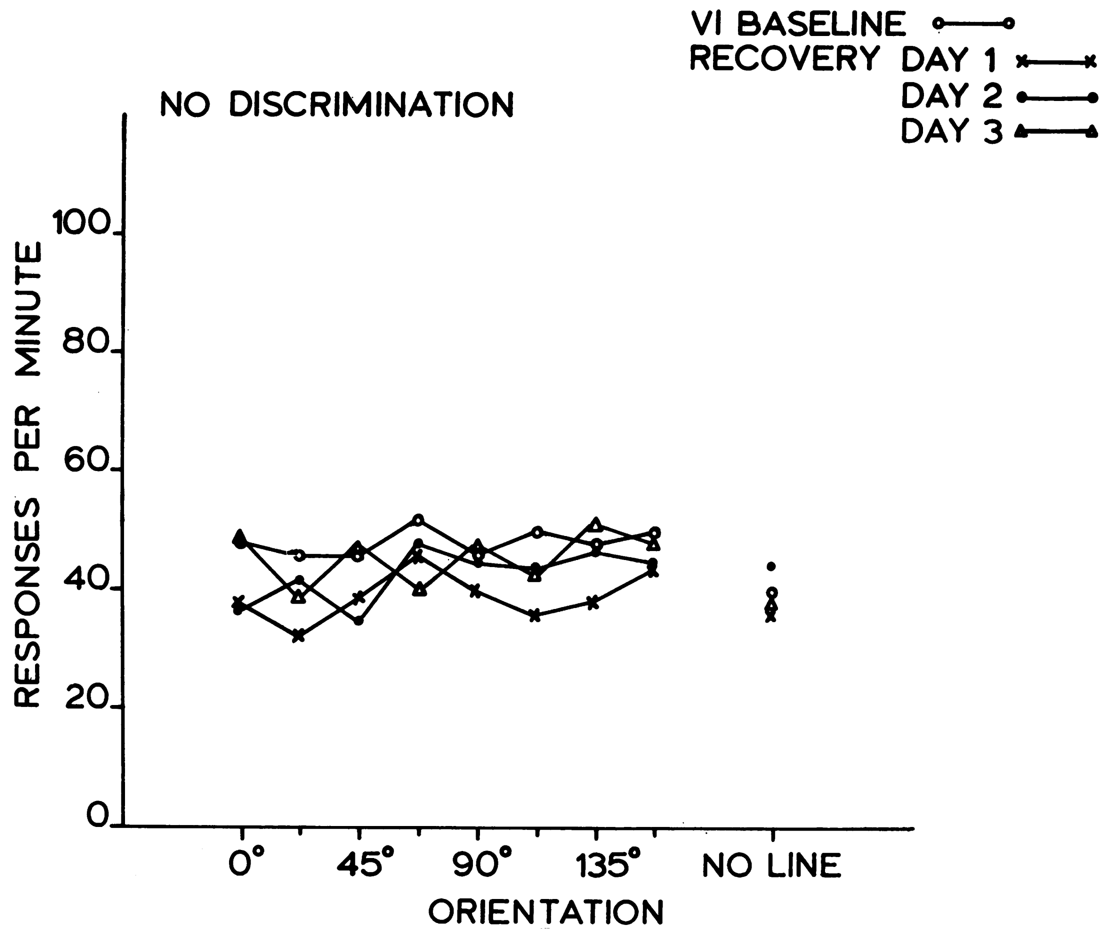

Fig. 2. Response rates obtained from the no-discrimination group at the end of VI training (VI baseline) and during three recovery sessions following punishment.

pression around the punished value, the gradient is not markedly steeper than the VI baseline, on which a similar depression was obtained. In general, response rates are 8 to 10 responses/min above the baseline during initial recovery, indicating that this was quite a rapid process.

The general impression based on inspection of the figures is supported by data for specific subjects presented in Table 2. In order to assess the reduction of responsiveness at and near the warning stimulus, the rate of responding to this value and the immediately adjacent stimuli (±22½°) has been divided by the total response rate to all eight stimuli involving presentation of the three lines. If the gradient is flat, this ratio should be close to .375, since responses to the three central values should comprise 37.5% of the total responses to the eight stimuli. With a reduction at and near the punished value, the ratio is depressed. The ratios obtained from the prepunishment VI baselines are all close to the expected value of .375, and the group averages differ by no more than .02. The ratios for the first recovery session show a marked and consistent depression for the discrimination groups, and very little change for the other two groups. There is no overlap between the discrimination group and the other groups, either for the "recovery ratios" or for the amount of change between VI ratio and the recovery ratios, as indicated in the "difference" column. Thus, the difference in the punishment gradients between the discrimination animals and the other groups was not only marked, but also consistent for individual subjects.

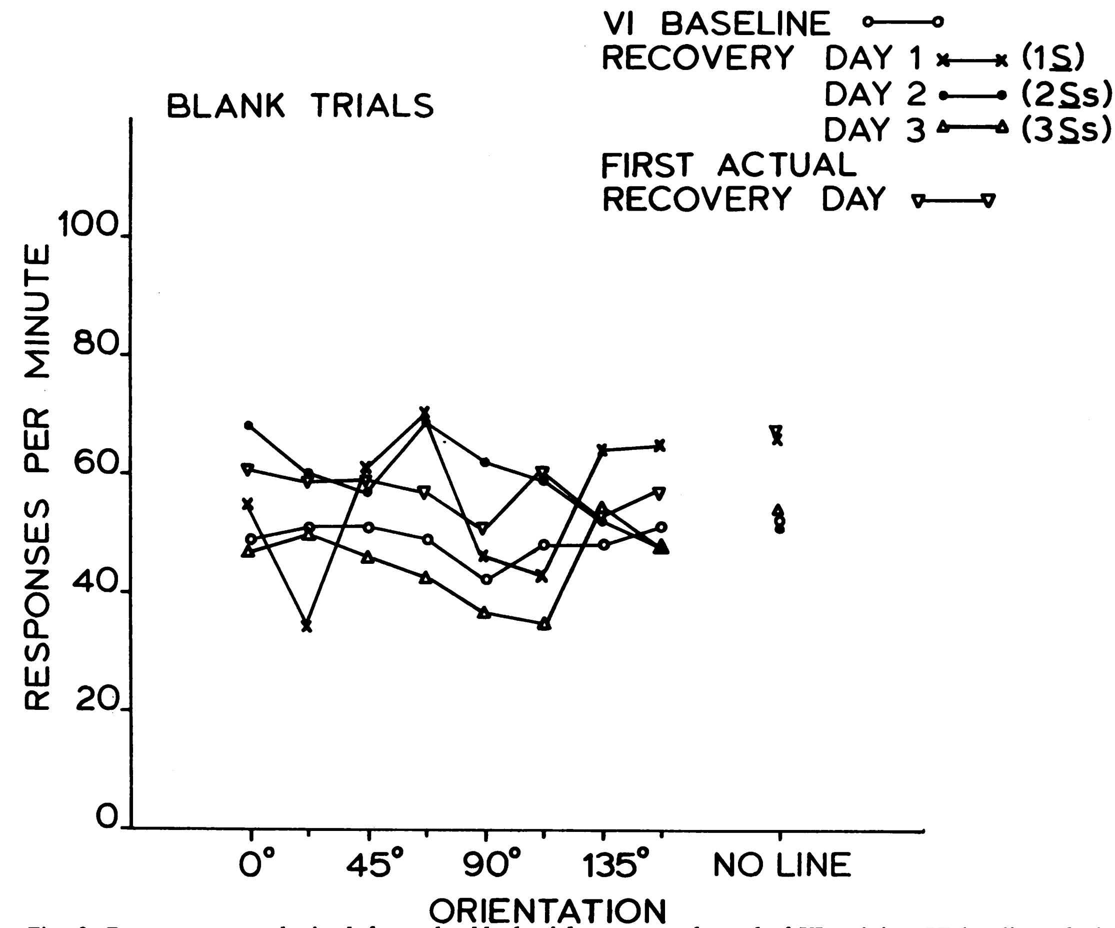

Fig. 3. Response rates obtained from the blank-trials group at the end of VI training (VI baseline), during three nominal recovery sessions, and during the first session of actual recovery (see text).

Table 2

Index of Responsiveness at The Central Gradient Values (67½°, 90°, 122½°) for The Last Five VI Sessions and The First Recovery Session

Discrimination Group	*VI Ratio*	*Recovery Ratio*	*Difference*
S 50	.35	.20	.15
S 55	.38	.29	.09
S 61	.38	.24	.14
S 65	.38	.23	.15
Mean	.37	.24	.13
No-Discrimination Group			
S 49	.37	.36	.01
S 53	.40	.41	—.01
S 67	.38	.40	—.02
Mean	.38	.39	—.01
Blank-Trials Group			
S 62	.37	.31	.06
S 64	.37	.36	.01
S 66	.34	.40	—.06
Mean	.36	.36	.00

DISCUSSION

The gradients of punishment obtained from the three groups in this study demonstrate that a discrimination between a warning stimulus and safe stimuli will greatly enhance the control exerted by a stimulus associated with punishment. Indeed, the simple pairing of a warning stimulus with punishment does not appear to change the form of the generalization gradient in any consistent manner. These findings support the results of Slivka and Honig (1964), who failed to obtain a punishment gradient along the spectral continuum with animals trained in a manner very similar to the present blank-trials group. On the other hand, it is clearly not necessary to provide explicit discrimination training between two values lying on the dimension on which stimulus control is examined by means of a generalization test. A discrimination between the warning stimulus and some stimulus orthogonal to the dimension in question is quite sufficient.

These results are parallel to those obtained by Newman and Baron (1965) and by Jenkins and Harrison (1960) with positive generalization gradients. Newman and Baron (1965) obtained decremental generalization gradients on the dimension of line orientation only after discrimination training between the presence (positive) and the absence (negative) of a white line on a background of constant color. A discrimination between backgrounds of different colors, for example, did not produce such a gradient. Similarly, Jenkins and Harrison (1960) obtained steep gradients on the dimension of tonal frequency only after discrimination training between the presence and absence of a tone of a single frequency. The conditions underlying the development of stimulus control appear to be quite similar for reducing responding due to punishment and for acquiring and maintaining behavior through reinforcement.

The generality of this conclusion may be questioned with reference to several studies on the spectral continuum (*e.g.*, Guttman and Kalish, 1956), and at least two studies with line orientation (Butter, 1963; Hearst, Koresko, and Poppen, 1964) where positive gradients have been obtained after simple acquisition on a VI schedule without any explicit discrimination training. But these studies differ in some important procedural ways from the present work on punishment. Initial training in the key-pecking situation with such stimuli present may provide an opportunity for discriminations to develop. The animal must learn to distinguish the illuminated target from its surroundings and must learn to aim its pecks at the key. A discrimination may also develop between stimulus-on and time-out periods, or between other aspects of the experimental situation. In the studies of line orientation, the relevant stimulus was a thin illuminated line on a dark background which comprised the rest of the response key. Thus, the contours of the line defined the response "target", while in the present study (and that of Newman and Baron, 1965) the lines were surrounded by illumination on the response key. The former arrangement is likely to enhance stimulus control by line orientation on the basis of perceptual factors alone. Since punishment must be imposed on behavior that is already maintained at some strength, such initial discriminations are well accomplished by the time punishment is introduced. Furthermore, since punishment (in a no-discrimination procedure) is systematically correlated only with stimuli produced by the punished response, any differential association is unlikely between the punishing stimuli and those aspects of the experimental environment already discriminated in the course of response acquisition.

According to this argument, the late introduction of punishment is one factor which prevents its association with a warning stimulus in the absence of discrimination training. A direct test of this would involve the introduction of punishment during original response acquisition, which is not a feasible procedure. This notion could also be tested less directly by introducing a positive stimulus late in training, and comparing the control exerted by it with the control that would be acquired early in response acquisition. If, for example, the response key were illuminated with a line or with some spectral value after responding to a blank white key is well developed, would the relevant gradients be as steep as when these stimuli are presented initially? This problem does not appear to have been studied. But Miles and Jenkins (1965) have shown that when tonal cues are added redundantly to a discrimination already established on the basis of brightness, they do not acquire as much control over the discriminative behavior as when they are initially present in discrimination training.

The possibility remains that the VI baseline training procedure prevented the appearance of a punishment gradient in the no-discrimination and blank-trial groups because it involved pretraining with a number of stimuli associated with identical reinforcement consequences before punishment was introduced. If this kind of "generalization training" induced a tendency for the subjects to discriminate various orientations, punishment effects could have generalized quite widely. This question cannot be resolved without a suitably designed experiment which avoids the baseline procedure. For example, one might carry out acquisition on the VI schedule only with the no-line stimulus and then introduce punishment in the manner used in this study, followed by recovery testing with the various line orientations. But there is also some evidence to indicate that a baseline procedure does not necessarily inhibit the formation of a negative gradient. Honig (1961) obtained a gradient of extinction on the spectral continuum after acquisition with a baseline procedure and extinction with a single stimulus value. Thus, while the baseline training may have flattened the punishment gradients (Honig found that the extinction gradients were flatter than acquisition gradients) it is unlikely that it obscured such gradients entirely.

The speed of recovery reflects those aspects of the punishment process which are likely to be affected by the intermittency of punishment and by the opportunity to associate the aversive condition with one selected stimulus. For the blank-trials group, punishment was continuous, and the suppression of responding appears to have been largely "emotional". This suppression lasted for varying periods of time into the recovery phase, but once a subject started to respond without being punished, recovery was very rapid. For the no-discrimination group, punishment was intermittent. These animals maintained some responding during safe periods and made a rapid initial recovery, but this was not complete, and the baseline was not fully reattained. The comparison between these groups supports the work of Azrin, Holz, and Hake (1963) who found that recovery was more rapid after continuous punishment than after intermittent. For the discrimination group, the suppression became specifically "attached" to the punished stimulus, while responding to the safe stimulus was maintained at a high rate. This process is reflected in the recovery data. There appears to have been no general depressive effect of an "emotional" nature, since several stimuli exceeded the baseline even on the first day of recovery; if anything, the cessation of punishment had a facilitative effect, as noted by Brethower and Reynolds (1962). By the end of recovery, responding to all stimuli exceeded the baseline.

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