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INTERACTIONS BETWEEN THE DISCRIMINATIVE AND AVERSIVE PROPERTIES OF PUNISHMENT[1]

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Punishment acquires a discriminative property when it is selectively paired with either reinforcement or extinction. At the milder punishment intensities, the discriminative control exerted by punishment is similar to the discriminative control exerted by a response-produced neutral (nonaversive) stimulus. However, the effect of the aversive property is apparent as the intensity of the punishment is increased. The aversive property of the punishment acts to enhance the discriminative control when the punishment is selectively applied during extinction periods, and to attenuate the discriminative control when the punishment is selectively applied during reinforcement periods. One major difference was found between the control exerted by the punishment and the response-produced neutral simulus: Responding greatly increased after the S^{Δ} punishment but not after the S^{Δ} neutral stimulus; this increase in responding was independent of the punishment intensities studied.

Electric shock is frequently used as a punishing stimulus. Any resulting reduction of responding is usually attributed to the aversive property of these shocks. However, we have recently found that even nonaversive shocks will reduce responding if they have been selectively paired with extinction. These nonaversive shocks acquire a discriminative property which produces the same general effect as aversive shocks. The discriminative property of a punishing stimulus is so powerful that shocks which are genuinely aversive will actually increase responding if they have been selectively paired with reinforcement (Holz & Azrin, 1961).

These two properties of punishment, aversive and discriminative, may either work together to suppress responding, or they may work against each other. This experiment is a study of the interaction between the aversive and discriminative properties of electric shocks that are used as punishment.

A fixed-interval schedule of food reinforcement may be considered as a period of extinction followed by an opportunity for reinforcement. If punishment is applied only to the responses occurring during the initial portion of each fixed interval, the punishment is associated with extinction. Conversely, if punishment is applied only during the final portion of each interval, the punishment is associated with reinforcement. This method of pairing punishment with reinforcement provides extended observation of the discriminative control exerted by the punishment.

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METHOD

The subjects were two experimental naive, adult, male White Carneaux pigeons. They were maintained at 80% $\pm$ 10 g of their free-feeding body weights. The daily session was 4hr for one subject on an FI 4 food reinforcement schedule, and 5 hr for the second subject on an FI 5 schedule.

The experimental chamber measured 13 by 14 by 15 in. high, and it was enclosed within a lightproof, sound-attenuating compartment. The subjects responded by pecking a translucent disc which was normally illuminated by a white light. The reinforcement for this response was a 3-sec presentation of grain from a feeder magazine; and the punishment was an electric shock (60 cycles AC) for a duration of 75 $\pm$ 5 msec. This shock was delivered through a 10,000-ohm resistor to electrodes implanted in the pigeon's tail region. The electrical resistance of the pigeons was approximately 1000 $\pm$ 100 ohms (measured with a 50-mv AC input). The shock intensity will be specified in terms of the voltage that is applied through this arrangement.

Three different sequences of scheduling the electric shocks were used: (1) The shocks were produced by all of the responses during the last quarter of each interval, but by none during the first three quarters; (2) the shocks were produced by all of the responses during the first three quarters of each interval but by none during the last quarter; and (3) the shocks were produced by all of the responses during the third quarter, but by none during the first, second, or fourth quarters. For comparison, the conditions of no shock and shock for every response in the interval were also studied. In another phase of the experiment, a green light, which illuminated the response key, was used as a nonaversive discriminative stimulus: (1) The green light illuminated the response key continuously during the first three quarters of each fixed interval; or (2) the green light occurred as a response-produced flash (90 msec long) following each response during the first three quarters of fixed interval.

The performance was allowed to stabilize for a minimum of 50 hr under each condition. The electric shock sequences were administered in order: 1) No shock; 2) shock for responses during the first three quarters—20v, 60 v, 100 v, 10 v, 50 v (40 v was used instead of 50 v for one subject); 3) shock for every response—50 v; 4) shock for responses during the last quarter—50 v, 100 v; 5) no shock; 6) shock for every response—50 v; 7) no shock; and 8) shock for responses during only the third quarter—50 v. The main effects of the procedures were reversible, and the simple fixed-interval performance was recovered for both subjects.

RESULTS

Under the simple fixed-interval schedule (Fig. 1, first row), the performance was normal,

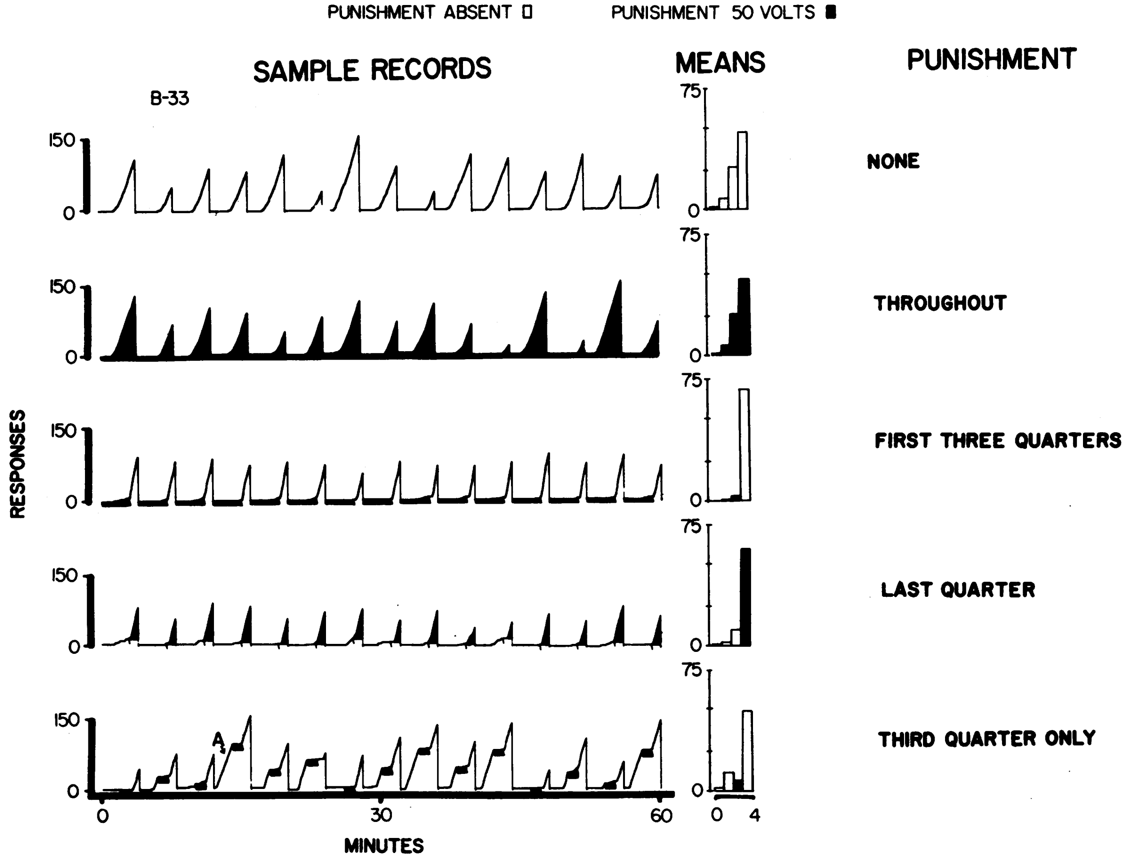

Fig. 1. General effects of selective punishment with a single punishment intensity (50 v). The sample cumulative-response records show the typical patterning of responses under different methods of applying punishment. Each bar graph represents the noncumulative mean responses in each quarter of 550 fixed intervals. The dark segments indicate the punis' ment periods.

and responding was positively accelerated between reinforcements. When every response was followed by a 50-v shock (second row), the resulting stable performance was essentially the same: the shock did not change either the total number of responses or the degree of acceleration of these responses. These results are in accord with previously reported findings (Azrin & Holz, 1961) that up to a certain intensity response-contingent electric shocks have no lasting effect upon fixed-interval responding.

A decidedly different performance resulted when shocks of the same intensity were selectively applied to responding. When the shocks were applied only to responses during the first three quarters of each interval (third row), these shocks greatly reduced the responding. When the shocks were applied only to responses during the last quarter of each interval (fourth row), these shocks actually increased responding. These effects follow directly from the discriminative property of the shocks. When the shocks occurred only during extinction periods, reinforcement was always temporally separated from the occurrence of a shock. The occurrence of shock therefore acted as an S^{Δ}. On the other hand, when the shocks were temporally proximate to reinforcement, the occurrence of a shock was the occasion for reinforcement and, hence, was an S^D.

When shocks were applied during the final portion of each interval, the absence of shock acted as an S^{Δ}. Consequently, the response frequency was reduced during the periods of no shock. Conversely, when the shocks were applied during the initial portion of each interval, the absence of shock acted as an S^D. Here, the response rate increased during the periods of no shock. The terminal rate increased from approximately 60 responses per minute (under the no-shock conditions) to approximately 90 responses per minute (under the condition of shock during the first three quarters).

When the 50-v shocks were applied to responses only during the third quarter of each fixed interval (fifth row, Fig. 1), the shocked responses were again separated from reinforcement. The response rate was low during these quarters. In the fourth quarters of the intervals, reinforcement occurred when responses were not shocked. This pairing of reinforcement and no shock was sufficient to establish the absence of shock as an S^D, so that the fourth-quarter responses increased in frequency. The responding during the first and second quarters also increased even though the responses were temporally separated from reinforcement. The discriminative control exerted by the absence of shock apparently generalized to the responding in the initial portions of the interval, and overrode the usual temporal control. (See A, Fig. 1.)

The upper portion of Fig. 2 shows that all shock intensities (10-100 v) greatly reduced responding when they were applied as an S^{Δ} (Figure 1 gives comparable data for the no-shock condition.) Even at a shock intensity of 10 v, the responses in the first three quarters were less than one-half the responses found when no shocks were applied. The higher shock intensities further reduced these responses, and the 100-v shocks virtually eliminated responding during the shock periods. At the very low intensities, the aversive property of the shocks was negligible, and only the discriminative property can account for the reduction. But as the intensity was in-

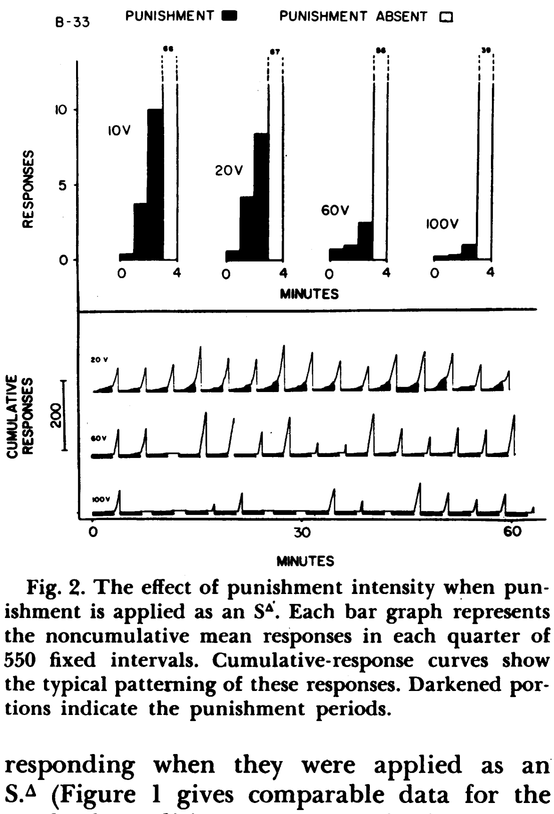

Fig. 2. The effect of punishment intensity when punishment is applied as an S^{Δ}. Each bar graph represents the noncumulative mean responses in each quarter of 550 fixed intervals. Cumulative-response curves show the typical patterning of these responses. Darkened portions indicate the punishment periods.

creased, the aversive property combined with the discriminative property to reduce responding further.

Figure 1 revealed an increase in the rate of responses following the period of S^{Δ} shocks. The lower portion of Fig. 2 shows that this increased response rate occurred at all shock intensities. At the most severe intensities, the initiation of responding was often delayed; but once responding began, it also occurred at this high rate.

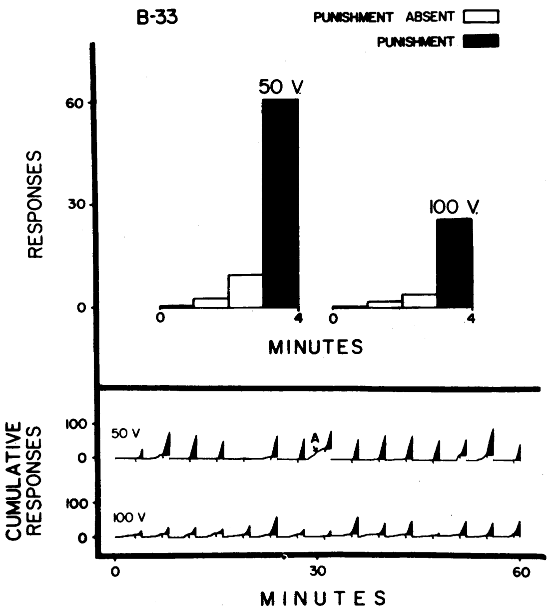

Fig. 3. The effect of punishment intensity when punishment is applied as an S^D. Each bar graph represents the noncumulative mean responses in each quarter of 550 fixed intervals. Cumulative-response curves show the typical patterning of these responses. Darkened portions indicate the punishment periods.

Figure 1 showed that 50-v shocks increased responding when they were applied as an S^D. Figure 3 shows that 100-v shocks attenuated the discriminative control and reduced responding. The aversive property overrode the tendency of the discriminative property to increase responding, but the low rate of the unpunished responses indicates that the discriminative control is still present.

These major effects reported for one of the subjects were also found for the second subject. Figure 4 summarizes the effects for this second subject.

Shock as a Discriminative Stimulus Compared With a Visual Discriminative Stimulus

In order to further evaluate the discriminative property of these electric shocks, a visual stimulus was programmed in a manner similar to that for the shocks. First, the response key was illuminated continuously by

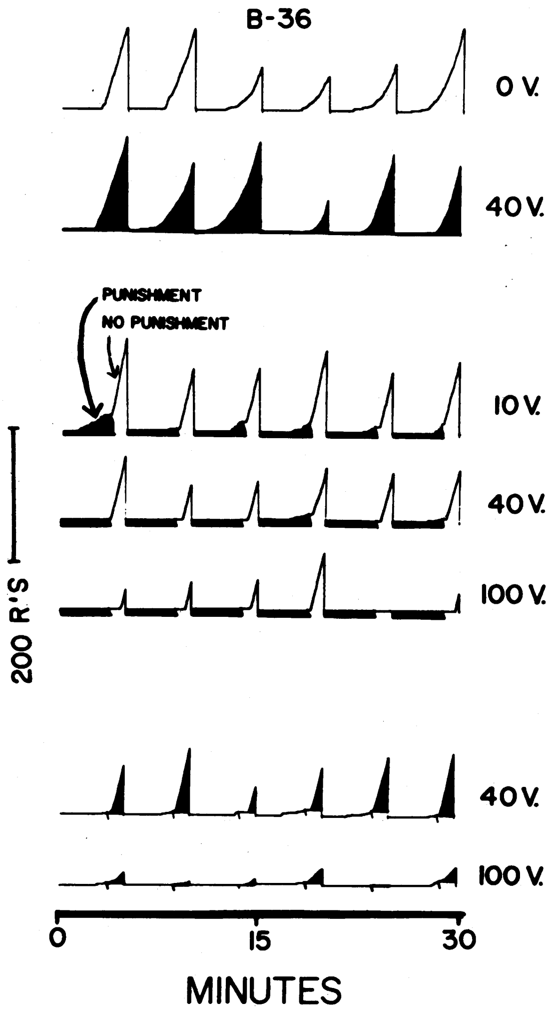

Fig. 4. The effect of selective punishment with the second subject. The cumulative-response records show the typical pattern of responding within the 5-min fixed intervals. The darkened portions of the curves indicate the punishment periods; the punishment intensity is shown to the right of the curves.

a green light during the first three quarters of each interval. This procedure converted the simple fixed-interval schedule to a multiple schedule in which extinction periods (green light) alternated with short fixed-intervals (white light). The upper part of

Fig. 5 shows the stable performance under this condition. Responding was virtually absent during the extinction periods of continuous green light. Next, the green light was scheduled as a short (90 msec) flash, which followed all responses during the first three quarters of each interval. This nonaversive S^{Δ} was similar to the shocks in that it was response-produced and it lasted for only a short time. The upper portion of Fig. 5 also shows the stable performance which resulted under this condition. Unlike the results on the continuous green light, some responding occurred during the S^{Δ} periods. However, this responding was clearly less than the responding during analogous periods of the simple FI 4. The responses during the extinction periods appeared to function as observing responses (Wyckoff, 1952; Kelleher, 1958), which displayed the S^{Δ}. The fact that some responding was necessary to display the discriminative stimulus seemingly accounts for their occurrence.

Comparison reveals that the 10-v shocks scheduled as an S^{Δ} had essentially the same effect as the response-produced flashes of green light. The cumulative-response curves in the upper part of Fig. 5 show that 10-v shocks reduced the responding to the same extent as the response-produced light. Even the patterning of the responses was similar. Thus, we may conclude that the discriminative control exerted by mild shocks is similar to the discriminative control exerted by traditional discriminative stimuli, when both stimuli are response-contingent.

Figure 5 shows that the rate of responding in the 1-min S^D periods varied with the preceding S^{Δ} condition. Enlarged segments of the cumulative-response curves are included in the lower portion of this figure. It will be noted that on the simple FI 1 schedule, a slight pause generally preceded responding in each interval. The responding then increased until a terminal rate was reached. When a 3-min extinction period associated with a continuous green light was introduced before each FI 1, the number of responses during the FI 1 increased. This increase was primarily due to a shorter pause; the positive acceleration and the terminal rate remained about the same. An increase in responding due to introduced extinction periods has been noted in other experiments (Ferster & Skinner, 1957; Reynolds, 1961), and has been called the "contrast" effect. Such a reinforcement contrast appears to be responsible for this change in the FI 1 responding.

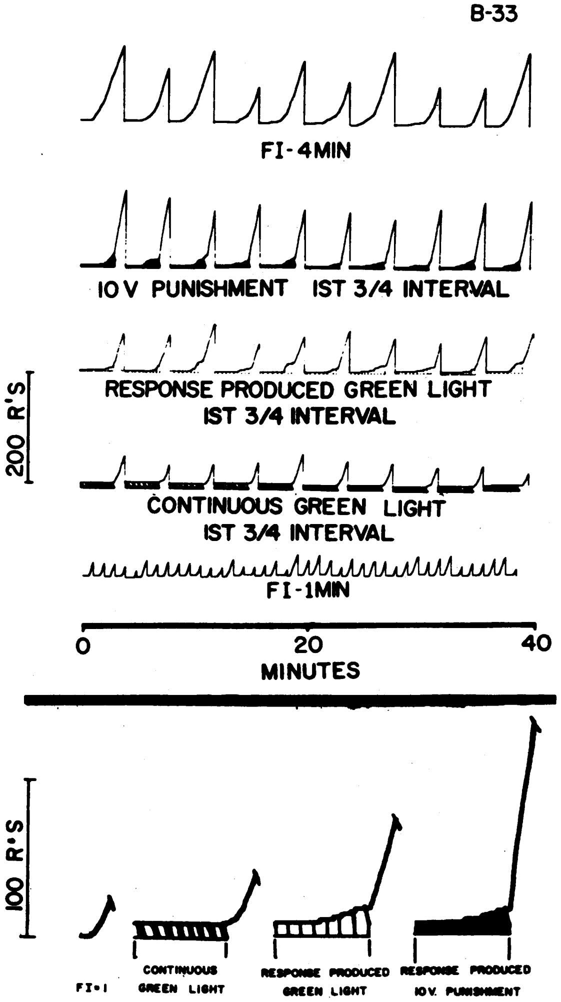

Fig. 5. Comparison of punishment with a nonaversive discriminative simulus. From top to bottom, the cumulative-response curves illustrate the performance when: (1) Responding is maintained on a simple FI 4 schedule; (2) 10-v punishment is applied to the first three quarters of each interval; (3) a 90-msec green light follows responses in the first three quarters of each interval; (4) a continuous green light is presented during the first three quarters of each interval; and (5) responding is maintained on a simple FI 1 schedule. The lower portion of the figure presents enlarged segments from the last four conditions.

When the 3-min extinction periods were associated with a response-produced green light, responding increased further during the FI 1 periods. This increase resulted from the immediate initiation of responding without positive acceleration; the terminal rate remained essentially the same. The increase resulting from this method of scheduling the S^{Δ} seems to be due to the absence of a definite starting point for the FI 1. Since the transition from the S^{Δ} to the S^{D} was not clear-cut, the temporal discrimination was apparently destroyed.

When the response-produced S^{Δ} was shock instead of the green light, a further increase resulted in the FI 1 periods. In this case, the terminal rate itself increased. Because such an increase in the terminal rate was not found after any other S^{Δ} condition, this increase would seem to be due specifically to the electric shocks. This increased responding is similar to the increase reported (Azrin, 1960) when the shocks were not differentially associated with reinforcement.

CONCLUSIONS

These results supplement previously reported findings (Holz & Azrin, 1961) that response-produced electric shocks (*i.e.*, punishment) can acquire a discriminative property. This discriminative property interacts with the aversive property of the shock to determine response frequency. Mild shocks produce essentially the same effect as a visual discriminative stimulus which is scheduled in the same manner. But when the shock intensity is increased, the aversive property of the shocks becomes apparent. If the shocks have been associated with extinction, the aversive property acts with the discriminative control and further reduces this responding. If the shocks are associated with reinforcement, the aversive property acts to attenuate the level of responding, but the discriminative control remains. Whenever punishment is differentially associated with reinforcement, a discriminative property will probably influence the effectiveness of the punishment.

Another finding from this experiment was that the termination of S^{Δ} shocks led to an increase in the unpunished responses which followed. This increase was independent of the intensity of the preceding shocks. Such an increase of responding following the termination of both effective and ineffective punishment has been observed before (Azrin, 1960). Therefore, the "compensatory" increase following punishment does not appear to be critically dependent upon the intensity of the shocks or upon the degree of response suppression (at least within the intensity range studied here). However, the purely discriminative stimulus did not lead to such an increase.

When mild punishment is used as an S^{Δ}, the responses are reduced below their normal level. This reduction is not so great as the reduction by an S^{Δ} that is continuously presented. At higher punishment intensities, however, the use of S^{Δ} punishment will reduce responding as greatly as a continuously presented S^{Δ}.

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