PUNISHMENT AND RECOVERY DURING FIXED-RATIO PERFORMANCE[1]

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When a reinforcement is delivered according to a fixed-ratio schedule, it has been found that responding occurs in a specific temporal pattern (Ferster & Skinner, 1957). Periods of no responding characteristically follow the delivery of the reinforcer. Once responding begins, it assumes a very high rate of several responses per second. The resulting performance is bivalued; responding occurs either at a high terminal rate or does not occur at all. Only under extremely low food deprivation or a high ratio requirement (Ferster & Skinner, 1957) does this pattern change significantly. The present report deals with the effects of punishment upon such fixed-ratio performance.

METHOD AND RESULTS

Six subjects (White Carneaux pigeons) were used, with varying sizes of ratios required for reinforcement (FR 10 to FR 50) and varying intensities of punishment (1-120 volts). The subjects were first conditioned to peck (respond) at an illuminated plastic disc, 1 inch in diameter. Reinforcement consisted of a 3-second exposure to grain. The punishment was a brief electric shock delivered through electrodes which were implanted in the subjects' backs. This method of delivering punishment is described in detail elsewhere (Azrin, 1959a).

Since the effects of punishment were comparable among the subjects, the results with one subject will be examined in detail. Performance was first stabilized under an FR 25 schedule of reinforcement. Body weight was held at 80% of the free-feeding value throughout the experiment. The punishment contingency was then added to the procedure. Following each response throughout each 15-minute daily session, a 0.05-second duration, 60-cycle A. C. shock was delivered through a 10,000-ohm series resistance. The subject's internal resistance was constant at 800 ohms, so that the voltage drop across the bird was about one-fourteenth the input voltage. Over a period of 120 days, the intensity of shock presentation was increased from a 1-to-120-volt input in the following order: 1, 3, 7, 10, 20, 40, 60, 80, 100, and 120 volts. Each value of punishment was maintained until the pattern and total number of responses showed no discernible trend over successive sessions. A minimum of three and an average of twelve sessions was given at each intensity of punishment.

Figure 1 shows the final performance under different intensities of punishment. At 0 volt (prepunishment), responding can be seen to occur at the high rate characteristic of fixed-ratio reinforcement. Slight pauses, of only a few seconds' duration, occur occasionally following reinforcement. At 40 volts, the only effect of the punishment is an increase of the postreinforcement pause for a minute or two at the beginning of the session. No reduction in responding occurs after this initial effect, and the total number of responses for the session is only slightly reduced.

At 80 volts, the total number of responses is reduced to approximately one-half of the prepunishment level. This reduction of responding does not extend throughout the session. Rather, the over-all rate is extremely reduced for the first 10 minutes, but almost completely unaffected thereafter. It can be seen that the action of the punishment is selective.

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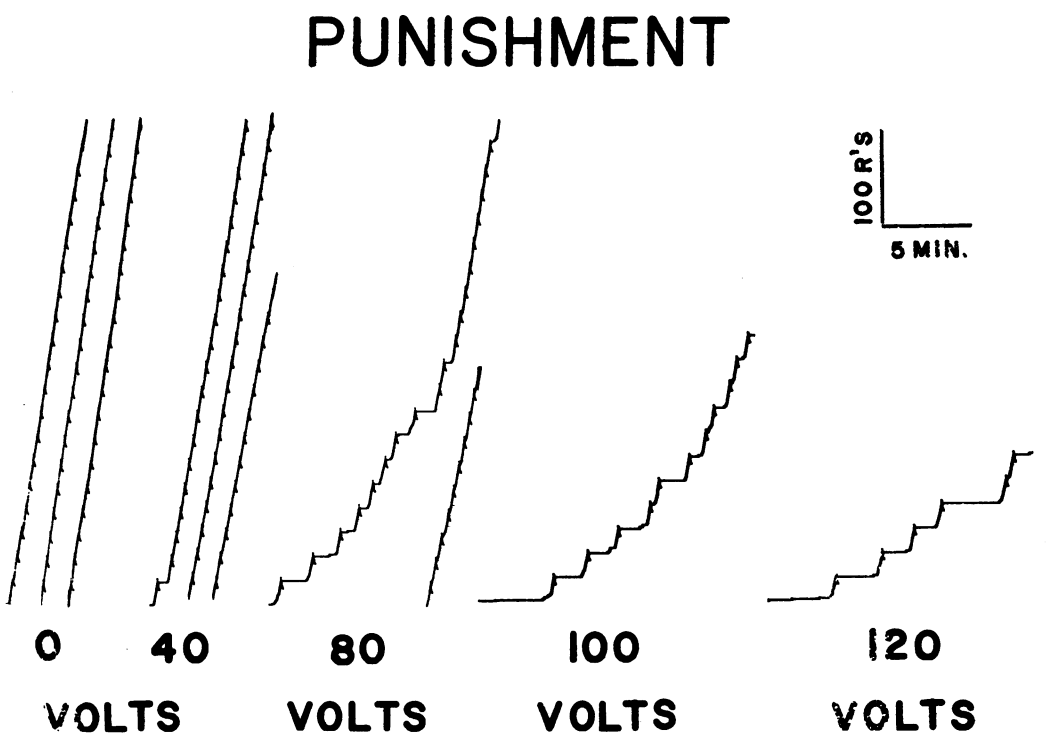

Figure 1. The effect of various punishment intensities on fixed-ratio performance. One complete daily session of 15 minutes is shown for each of the values of punishment. The punishment is delivered immediately following every response. The oblique pips on the curves indicate the delivery of the food reinforcement.

Once responding occurs, it usually proceeds at the same high terminal rate that prevailed before punishment. The reduction in the over-all number of responses is primarily a consequence of lengthening the pause after reinforcement. In the beginning of the session, at 80 volts, the pauses can be seen to endure for several minutes, becoming briefer after successive reinforcements until there is virtually no pausing by the end of the session.

At 100 volts, the selective action of punishment can be seen even more clearly. The reduction in the total number of responses is again attributable to the increase in pauses rather than any reduction in the ongoing rate. Again, responding accelerates throughout the session; this acceleration is a function of the progressively decreasing pauses following reinforcement. At 120 volts, the punishment has reduced the total number of responses to a small fraction of the prepunishment number. Again, each reinforcement is followed by a long pause; but once responding begins, only a few responses are necessary before the high local rate emerges. Unlike the lower punishment intensities, there is now usually a trickle of responses prior to the high terminal rate. Also, in contrast to the lower punishment intensities, the severe 120-volt punishment allows little or no recovery throughout the session. Long pauses exist at the end as well as at the beginning of the session.

In changing from one intensity of punishment to another, large sequential changes are produced. This can be seen from Fig. 2, which shows the transient, as well as the more permanent, effects of increases in the intensity of punishment. As can be seen from Fig. 2 (top), the initial increase from 10 volts to 20 volts reduces the total number of responses

markedly and disrupts the characteristic fixed-ratio pattern of pausing and response-bursts. By the fourth day under 20 volts, however, the effect of the punishment is restricted to the early part of the session and consists mainly of an increase of the postreinforcement pause. By the fifth day, the effect of the punishment is seen only as a slight increase in the time taken to initiate responding in the beginning of the session. As another instance of the disruptive effects of changes in punishment, Fig. 2 (bottom) shows the effects of increasing the punishment from 60 volts to 80 volts. Again, the first day under the increased punishment reveals a severe disruption of the pattern of responding as well as a large reduction in the total number of responses. In the succeeding sessions (see Sessions 10 and 15) under 80 volts, the reduction of responding becomes progressively restricted to the initial part of each session. Also, the postreinforcement pauses become progressively longer, with little change in the terminal rate once responding begins.

DISCUSSION

It is seen that punishment affects fixed-ratio performance by selectively increasing the postreinforcement pause. The greater the intensity of the punishment, the longer the pausing. Once responding begins, the local rate remains virtually unchanged regardless of the

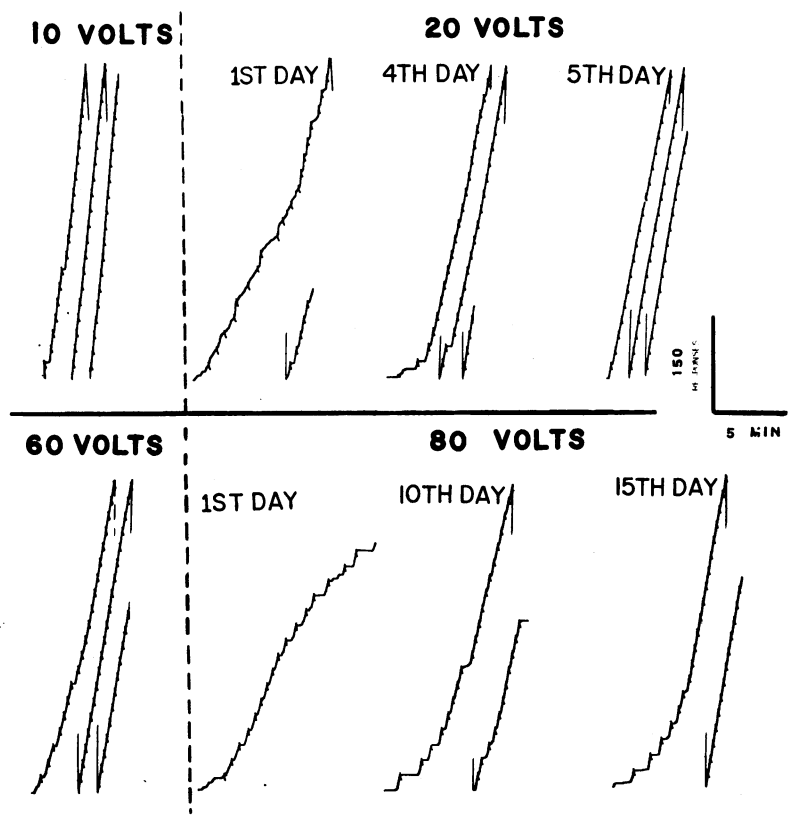

Figure 2. Transient vs. stable changes in performance when punishment intensity is increased. Each group of curves represents the performance for one complete session. Punishment is delivered immediately following each response. Reinforcement (FR 25) is indicated by the oblique pips on the curves.

intensity of punishment. Any reduction in the total number of responses by punishment, therefore, is attributable to an increase in the pauses, not to any decrease in the local rate of responding. A similar result has been obtained in a study of the effect of punishment on the fixed-interval behavior of humans (Azrin, 1958), in which punishment was found to increase the duration of the postreinforcement pause but to leave the fixed-interval terminal rate relatively unaffected. This result is comparable with the results obtained by Ferster and Skinner (1957) and those of Sidman and Stebbins (1954) regarding the effects of satiation on fixed-ratio performance.

In contrast to the selective effect of punishment on fixed-ratio performance, the effect of punishment on variable-interval performance is more general. Previous studies (Azrin, 1959b) have found that punishment during variable-interval performance produces a general reduction of responding, with no basic change in the temporal pattern such as is seen here.

Visual Observation during Punishment

Direct visual observation of the subjects in the present investigation reveals a somewhat dramatic sight during severe punishment (80-120 volts). Immediately following reinforcement, the subject usually moves completely away from the location of the response key. When the subject eventually returns to the key and executes the first response, the punishment produces a violent lurching and fluttering of the wings. The violence of the physical reaction to this single punishment makes it seem unlikely that another response will be emitted for some time. Nevertheless, the subject executes the remaining 24 responses in extremely rapid succession, in spite of the fact that the physical effect of the punishment seems to make it difficult to maintain an erect posture, much less respond.

Recovery From Punishment

In each of the response records presented, responding was especially reduced during the initial part of each session of punishment, with progressive recovery during and between the sessions. This same recovery phenomenon was seen to occur between sessions as well as within them. The factors determining this recovery from punishment are still unknown. Indeed, the very existence of such recovery has not been noted previously in otherwise fairly extensive studies of punishment (Estes, 1944). Yet, this recovery effect seems to constitute one of the most dramatic effects of punishment. It should be noted that this recovery is not unique to situations in which implanted electrodes are used as the punishment, since the same recovery process also has been noted when an electrified grid (Azrin, 1956) has been used.

SUMMARY AND CONCLUSIONS

The effect of punishment on fixed-ratio performance is to increase the duration of pausing following reinforcement. No reduction in the local rate of response occurs, almost regardless of the severity of the punishment. Any reduction of the total number of responses is therefore attributable to an increase in pausing, *not* to any decrease in the prevailing rate of responding.

This reduction of responses is greatest at the time of the initial introduction, or increase, of the punishment. Progressive recovery then occurs after continued exposure and is virtually complete at moderate intensities of punishment that had initially reduced responding markedly. However, the reduction of responding by even moderate punishment is usually

still evident at the very beginning of each session, though complete recovery had occurred during the latter portions of the previous sessions. At higher, almost physiologically intolerable, intensities, recovery from the initial effect of punishment is only partial.

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