Recovery from punishment of bar pressing maintained on fixed and variable interval reward schedules¹

LOWELL H. STORMS AND GEORGE BOROCZI, *NEUROPSYCHIATRIC INSTITUTE, U C L A*
WILLIAM E. BROEN, JR., *UNIVERSITY OF CALIFORNIA, LOS ANGELES*

Abstract

Twenty-four rats maintained on 2 min. FI food reward and 24 on 2 min. VI reward were shocked for every bar-pressing response until responding ceased. Shock durations were .1, .2, .4, .8, 1.6, and 3.2 sec., with four Ss from each group assigned to each duration. The reinforcement schedules did not differ in number of shocks required to produce suppression of responding. However, 2 weeks later in 3 retest sessions with reward but without punishment, the effects of punishment were more durable for the VI than for the FI schedule. Recovery of FI responding was a monotonic decreasing function of shock duration, while the least recovery of VI responding occurred at an intermediate duration, 4 sec.

Problem

Although there has been some experimentation regarding the effects of punishment on responses maintained on various reinforcement schedules (Azrin, 1959, 1960; Azrin & Holz, 1961), recovery from punishment effects has not been related to reinforcement schedules. It is of particular interest to compare VI and FI schedules. It has been stated that VI reward leads to more persistent responding in extinction than FI reward (Skinner, 1953, p. 389), and this statement has received some empirical support (Ferster & Skinner, 1957). If this reflects greater strength of VI rewarded response tendencies, it would be expected that VI rewarded responses would be more resistant to the effects of punishment than FI rewarded responses. The major purpose of the present study was to compare ease of suppression and recovery from punishment of a bar-pressing response maintained on 2 min. FI and 2 min. VI food reward schedules.

A further purpose was to investigate the relationship between duration of shock and recovery from punishment using an extended range of shock durations as compared with previous studies in this series. (Storms, Boroczi, & Broen, 1963; Boroczi, Storms, & Broen, 1964).

Method

Forty-eight Long-Evan male rats, all approximately 100 days old, served as Ss in the experiment. The animals were obtained from Adams Laboratories of San Gabriel, California.

The apparatus consisted of four identical Davis Skinner boxes. Pressing of a lever delivered a .05 gm spherical pellet according to the desired reinforcement schedule. Electric shocks were delivered through the

grid floor of the boxes and were supplied by a Davis shocker and grid-scrambler apparatus. Resistance of 150,000 ohms was wired in series with the rat.

The procedure was similar to the procedure described by Storms et al (1963). Prior to the beginning of the experiment, the animals were handled daily and maintained on a 1-hr. daily feeding schedule for a period of six days. They were then trained to press the bar to obtain the pellets. Over the following two daily 1-hr. sessions at 23-hr. food deprivation the reinforcement schedule was gradually lengthened from continuous to a 2-min. FI schedule. At this point the animals were divided randomly into two groups of 24 each. One group was maintained on the 2-min. FI reinforcement schedule and the other group put on a 2-min. VI schedule for six additional 1-hr. daily sessions. For the VI group, seven different reinforcement intervals (30, 60, 90, 120, 150, 180, and 210 sec.) were given in a randomized order before a new random order started. Following each session, the animals were fed in their cages as much mashed Purina rat food as they could consume in 1 hr.

Following the six sessions with 2-min. VI or FI food reinforcement, punishment contingent upon each bar press was introduced in the form of .8 ma electric shocks with the assigned food reinforcement schedules effective. The six shock durations were; .1, .2, .4, .8, 1.6, and 3.2 sec. Accordingly, the Ss in each reinforcement condition were further subdivided randomly into six shock duration groups of four rats each. Punishment of the bar-pressing response was continued until no bar pressing occurred during a full 1-hr. daily session. Four Ss did not meet the criterion of cessation of responding within eight sessions of punishment and were subsequently replaced by four additional Ss. Once the criterion of cessation was reached, the animals were returned to their individual cages for a period of 14 days, during which the 1 hr. per day feeding schedule was continued with water available ad lib. Following this period of rest, the Ss were retested on three successive days, 1 hr. each day, under 23-hr. food deprivation, with their assigned reinforcement schedules in effect but with no punishment for responding.

Results

There was no statistically significant difference between the two reinforcement groups in number of responses during the last session of training before

punishment ($F < 1$) and also no significant differences were found among the groups which were to receive different durations of shock ($p > .05$).

The two reinforcement groups did not differ in number of punishments required to produce cessation of responding ($F < 1$). The differences in number of shocks to cessation among the six shock duration groups were highly significant ($F = 7.35$, $df = 5/36$, $p < .01$). Longer shock durations were associated with fewer shocks to cessation of responding, although the longest durations had little added effect. The reinforcement schedules $\times$ shock duration interaction was not significant ($F < 1$).

For the analysis of the recovery data, a score of 1 or 0 was assigned to each S for each session of retest according to whether or not the S had recovered in that session (recovery = resumption of bar pressing, which is an all-or-nothing effect; see Storms et al, 1963). The recovery scores for the two reinforcement groups for the six shock durations are plotted in Fig. 1. The difference between the reinforcement groups was statistically significant ($F = 6.27$, $df = 1/36$, $p < .05$), with more Ss recovering in the FI group than in the VI group. Also significant were the main effects for shock duration ($F = 2.72$, $df = 5/36$, $p < .05$) with longer durations associated with less recovery, and for days of retest ($F = 15.39$, $df = 2/72$, $p < .01$) with increased recovery the longer the Ss were retested. None of the interactions was significant.²

Independent tests were performed for the two reinforcement schedule groups as a further analysis of the effects of shock duration on recovery scores. The cubic trend was significant for the VI group ($F = 5.53$, $df = 1/18$, $p < .05$); while for the FI group the linear trend was significant ($F = 9.53$, $df = 1/18$, $p < .01$). The residual effects did not approach significance for either of the two groups.

Discussion

Since a previous experiment (Boroczi et al, 1964) found differences in recovery (comparing .8 and 1.0 ma shocks) which were not evident in the number of punishments required to produce cessation of responding, it is not entirely surprising that the FI and VI schedules differed only on recovery scores.

It is notable, however, that the effects of punishment were more durable for the VI schedule than for the FI schedule. Since nonreward after training on a VI schedule may result in greater resistance to extinction than for an FI schedule (Ferster & Skinner, 1957), one might surmise that VI schedules lead to stronger habits which should be more resistant to the effects of punishment. The opposite was the case in this experiment, suggesting that responses reinforced on a VI schedule are, if anything, weaker than FI reinforced

Fig. 1. Total rat-days during which Ss in each group were responding in retest sessions.

responses, since VI responses recover less from punishment. The possibly greater resistance to extinction of VI responding when reward is discontinued may be due not to stronger response tendencies but to the greater difficulty VI reinforced Ss have in discriminating the situation where reward is unavailable from one where reward is available.

Over the range of shock durations used in previous studies (Storms et al, 1963; Boroczi et al, 1964), there was no relationship between shock duration and recovery ($F < 1$), but with an extended range (.1 to 3.2 sec. as compared with .2 to 1.0 sec.), longer shock durations were associated with less recovery in the FI group. For the VI schedule, an intermediate punishment duration, .4 sec., led to the most durable suppression, none of the four rats recovering at any time. This striking middle duration effect was also found in a previous study (Storms et al, 1963).

References

- Azrin, N. H. Punishment and recovery during fixed-ratio performance. *J. exp. Anal. Behav.*, 1959, 2, 301-305.
- Azrin, N. H. Effects of punishment intensity during variable-interval reinforcement. *J. exp. Anal. Behav.*, 1960, 3, 123-142.
- Azrin, N. H., & Holz, W. C. Punishment during fixed-interval reinforcement. *J. exp. Anal. Behav.*, 1961, 4, 343-347.
- Boroczi, G., Storms, L. H., & Broen, W. E., Jr. Response suppression and recovery of responding at different deprivation levels as functions of intensity and duration of punishment. *J. comp. physiol. Psychol.*, 1964, 58, 456-459.
- Ferster, C. B., & Skinner, B. F. *Schedules of reinforcement*. New York: Appleton-Century-Crofts, 1957.
- Skinner, B. F. *Science and human behavior*. New York: Macmillan, 1953.
- Storms, L. H., Boroczi, G., & Broen, W. E., Jr. The effects of punishment as a function of strain of rat and duration of shock. *J. comp. physiol. Psychol.*, 1963, 56, 1022-1026.

Notes

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2 An identical analysis was performed on number of responses during the retest sessions with essentially the same results.