SELECTIVE PUNISHMENT OF FIXED-RATIO PERFORMANCE¹

J. F. DARDANO² AND D. SAUERBRUNN

ANNA STATE HOSPITAL³

Key-pecking of pigeons, maintained by an FR 50 grain reinforcement schedule, was punished by shocking the first, middle, or last response of the ratio. Under high shock levels, the three punishment conditions produced differential effects on the behavior. Punishment of the first response of the ratio resulted in consistent and extended post-reinforcement pausing and frequent extended breaks after the initial response(s) of the ratio. Punishment of the 25th response disrupted responding in the first half of the ratio with little effect on the last half of the ratio. Punishment of the final response resulted in breaks and local rate changes in various parts of the ratio. Durations of pauses after reinforcement were more variable when the 25th and 50th responses were punished relative to those when the first response was punished.

The behavior generated by a fixed-ratio (FR) reinforcement schedule consists of a post-reinforcement pause followed by a uniform, high running rate. This bi-valued rate has been ascribed to the chaining of the responses comprising the ratio (Ferster and Skinner, 1957). Punishment of each response of a short FR did not modify the bi-valued rate; the effect on performance was an increase in the duration of post-reinforcement pauses (Azrin, 1959b). The present study concerns the punishment of a single response of a short FR. A comparison was made of the effects of selectively punishing the first, 25th, and 50th responses of an FR 50.

METHOD

Subjects

Six male White Carneaux pigeons, between two and three years old at the start of the study, were used. Their histories consisted of short FR reinforcement schedules with the exception of B-47, which also included various VR and VI schedules. None of the Ss had ex-

perience with electric shock. All Ss were maintained at 75% of their free-feeding weight; pre-session body weights averaged 73-74% of free-feeding weight. The Ss were housed in separate units with continuous access to community grit and water. A list of the Ss and their electrical resistances for sessions in which shock was administered are included in Table 1.

Apparatus

The 14 by 14 by 14.5 in. experimental chamber, of wooden construction except for a metal front panel and plexiglass window, was set within a refrigerator compartment. Continuous masking noise and ventilation were provided. A translucent key, closed by a force of approximately 15 g, was located 9.5 in. above the wire mesh floor and 1 in. to the right of center of the front panel. A relay mounted on the exterior of the front panel provided response feedback. The opening to the raised grain tray was centered at the bottom of the front panel. The reinforcer was a 3-sec exposure to a grain mixture, individual seeds of which did not pass $\frac{1}{8}$ in. sifting holes. The white house light and key light were on continuously except during the reinforcement period.

A regulated line current was connected by a relay to a circuit consisting of the pigeon, a milliammeter, and a 10 K resistor. Shock was applied to the pigeon by fixed electrodes (Azrin, 1959a). Duration of the shock was .05 sec. In this report, shock intensity is specified

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²Reprints may be obtained from J. F. Dardano, Dept. of Psychology, University of Rhode Island, Kingston, Rhode Island.

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Table 1

Summary of Electrical Resistance in Ohms, Experimental Conditions, and Number of Sessions under Each Condition for Each S. Shock Conditions are Listed in Order of Administration for Those Ss Exposed to More than One. Shock Level in ma.

S	Resistance		Number of Sessions	Shocked R and Shock Level in ma
	Mean	Min-Max		
B-47	1323	970-1390	48	R-1: 3.0, 6.2, 9.4
			37	R-50: 3.0, 6.2
			7	R-25: 6.2
B-52	835	690-980	118	R-25: 1.4 to 15.8, steps of 1.6
B-57	1182	620-1990	124	R-50: 1.4 to 12.6, steps of 1.6
			60	R-25: 3.0, 6.2, 9.4, 12.6
			73	R-1: 3.0, 6.2, 9.4, 12.6, 15.8
B-63	1227	1010-1390	128	R-1: 1.4 to 15.8, steps of 1.6
			40	R-50: 3.0, 6.2
B-75	830	680-910	70	R-50: 3.0, 6.2, 9.4, 12.6, 15.8
B-81	852	810-960	22	R-50: 3.0, 6.2

in terms of the milliammeter readings when a 1 K fixed resistor was substituted for the pigeon and various voltages applied. Delivery of shock was programmed by a pre-selector counter activated by each response. Speed of the cumulative recorder was 60 cm/hr.

Procedure

Each S had one session each day, seven days a week. Duration of each session was 1 hr or delivery of all programmed reinforcements, whichever occurred first. Number of reinforcements in a session was constant for a given S and ranged from 40 to 60 among Ss. Electrical resistance of the S was measured before and after each session.

Each S was maintained on an FR 50 for a minimum of 35 sessions (1400 reinforcements) before the first exposure to shock. When the overall rate and response pattern appeared stable over several sessions, one of the following three shock conditions was introduced: shock on the first response of the ratio (R-1 shock), shock on the 25th response (R-25 shock), or shock on the 50th response (R-50 shock). Most Ss were exposed to several intensities under each shock condition. Each shock level was continued until the response rate and pattern failed to show any trend or gross deviation for a minimum of five consecutive sessions. The shock intensities under a given shock condition were administered in increasing order of magnitude, and all shock levels were administered under one shock condition before changing S to another shock condition. Several sessions without shock were introduced between different shock conditions, but

not between different shock intensities under a given condition.

It was planned to expose each of three Ss, B-52, B-57, and B-63, to each of the three shock conditions. However, B-52 did not regain a stable FR performance after R-25 shock, and B-63 did not regain a stable FR performance after the R-50 shock condition which had followed the R-1 shock condition. Therefore, additional Ss were employed to replicate the findings. The shock condition(s) to which each S was exposed, the number of sessions under each shock condition, and the shock levels used with each shock condition are shown in Table 1.

RESULTS

R-1 Shock. The effects of intense punishment of the first response included prolonged pauses after reinforcement (PAR), extended breaks after the initial response(s) of the ratio, and rough grain at the start of the ratio. After the terminal rate was initiated, responding was sustained and occurred at the pre-shock rate. The performances of B-63 under 12.6 and 14.2 ma in Fig. 1 illustrate these effects. Since no ratios were completed after the first session under 15.8 ma, B-63's performance under 14.2 ma illustrates the maximum impairment by the R-1 shock contingency when ratios were completed in a session. Prolonged raggedness before initiating the run and breaks after several responses of the run occurred infrequently under R-1 shock. These properties were present in 41 of the 530 ratios completed by B-63 under 12.6 and 14.2 ma and are illus-

Fig. 1. Pre-shock performance and final performances for four shock levels under R-1 shock for B-63. Two sessions are shown for 14.2 ma. Complete sessions are shown except for sessions under 14.2 ma. Overall rate is indicated for each session.

trated by the fifth and ninth ratios under 12.6 ma and the first ratio under 14.2 ma.

At lower shock levels, the only consistent effect of the R-1 shock was an increase in the duration of PAR. Examples of the final performance of B-63 under 4.6 ma, the first shock level with a non-transient effect, and 7.8 ma are shown in Fig. 1. In the final behavior under the various shock levels, overall response rate and average duration of PAR were proportional to the shock level.

R-25 Shock. Intense punishment of the 25th response markedly affected responding in the first half of the ratio. This localized effect primarily consisted of bursts and breaks of various durations. Responding in the last half of the ratio was sustained and initiated immediately after delivery of shock. The durations of the PAR were extremely variable. These effects can be seen in the performance of B-52 under 14.2 ma in Fig. 2.

At lower shock levels, the disruption consisted of a brief break after the shocked response or a few responses emitted at a lower rate in the vicinity of the shock as seen in the performance under 12.6 ma in Fig. 2. Under

Fig. 2. Pre-shock performance and final performances for three shock levels under R-25 shock for B-52. All records are complete sessions with overall rate listed for each session. In the record for 14.2 ma, the pen reset after each reinforcement and pip denotes shock.

3.0, 4.6, and 6.2 ma, the overall rate of B-52 was higher than the pre-shock overall rate. Other Ss exposed to the R-25 shock condition did not exhibit this facilitation; however, their pre-shock overall rates were appreciably higher than that of B-52.

R-50 Shock. In contrast to the localized effect of the R-1 and R-25 shock contingencies, intense punishment of the final response resulted in irregularities at various points of the ratio. The most common effects were brief response breaks and local rate changes. In addition, decelerations at the end of the ratio and a lower running rate throughout a ratio occurred occasionally. Although the average duration of PAR in a session increased, many of the ratios exhibited an extremely brief PAR. An example of the final performance of B-47 under R-50 shock is shown in Fig. 3.

The severe disruption by a low shock level also occurred with B-47 under the other shock conditions. At shock levels below that level which produced marked changes in performance, the effects of the R-50 shock condition were slight for all Ss.

Ratios abstracted from the cumulative records of B-47 are shown in Fig. 4 to illustrate the differential effects of the three shock conditions on the responding within a ratio. The shock intensity was 6.2 ma for the sessions from which the ratios were taken. Overall rates for the sessions were .6 responses/sec for the R-1 and R-50 shock conditions and 1.5 responses/sec for the R-25 condition. This was

Fig. 3. Pre-shock performance and final performance under R-50 shock for B-47. Overall rate is shown for each session. In lower record, first 6 min of session, 13 min at "A", and final 17 min starting at "B" were deleted from the record. No responses were emitted in the parts of the session which were deleted.

the lowest overall rate available for B-47 under R-25 shock.

Development of Suppression. The prominent characteristics of the performances associated with each shock condition persisted

Fig. 4. Ratios from a session under each shock condition for B-47. The shocked response is indicated on the left. Shock intensity was 6.2 ma in the sessions. For the ratios under R-25 shock, the pip denotes delivery of shock, and the pen reset after each reinforcement.

Fig. 5. Suppression of the FR performance of B-57 under each shock condition. Shock intensities were 12.6 ma for R-25 and R-50 shock and 15.8 ma for R-1 shock. The shocked response is listed on the left. The session number is shown at the beginning of each record. Two sessions are shown for each shock condition; the second session was the last in which ratios were completed. For R-25 shock, the pen reset after reinforcement and the pip denotes shock. No responses occurred in the part of the session which is deleted.

under that shock level which eventually suppressed responding to the point at which no ratios were completed in a session. Two sessions from the suppression phase under each shock condition for B-57 are shown in Fig. 5. Each pair of sessions includes the last session in which a ratio was completed and one earlier session. Under R-25 shock, the latter sessions of the suppression phase contained some ratios which were disrupted throughout. An example of this loss of the localized effect is the fourth ratio in session 12. After the last session in which a ratio was completed under the R-1 and R-25 shock conditions, B-57 emitted the punished response in two sessions as did B-63 under R-1 shock and B-52 under R-25 shock.

Recovery from Punishment. After the shock level which produced maximum suppression was removed, the eventual completion of a ratio was followed by an abrupt recovery of responding. None of the Ss exhibited a gradual inter-session increase in response frequency. With the exception of B-63 under R-1 shock, all programmed ratios were completed in that session in which the first ratio was completed. The performances in those sessions in which responding recurred are shown in Fig. 6. The records of B-57 and one other S are shown for each shock condition. Two sessions are in-

after reinforcement. The presence of extremely long breaks immediately after the shocked response under the R-1 contingency, and the absence of such breaks after the shocked response under the R-25 contingency, might be due to the difference in the accumulated count at the occurrence of shock.

The non-localized deterioration of the performance under R-50 shock suggests a weakening of the control exerted by the FR reinforcement contingency. The occurrence of punishment at the start of the magazine cycle might have resulted in the shock acquiring conditioned reinforcing properties or the magazine cycle acquiring aversive properties. Another possibility is suggested by the finding of Ferster and Skinner (1957) that insufficient reinforcement of FR performance resulted in rough grain, intermediate rates, and little change in post-reinforcement pauses. The R-50 performance might have been affected by a reduction in grain intake due to the elicitation of respondents on the occasion for the eating behavior.

The performances under R-1 and R-50 shock show some similarity to the FR performances under shock programmed as a correlated block counter (Dardano and Sauerbrunn, 1964). When the maximum shock intensity occurred during the first third of an FR 100, the major effect was an increase in the duration of post-reinforcement pauses; when the maximum shock intensity occurred during the last third of the ratio, there were local changes in running rate without excessive pausing after reinforcement.

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