MULTIPLE PUNISHMENT SCHEDULE¹

DIANE DEARMOND

UNIVERSITY OF MISSOURI AT KANSAS CITY

Concurrent schedules of punishment and fixed-ratio reinforcement were studied in six white Carneaux pigeons. Two stimuli were alternated on the translucent key which served as the response mechanism. The pigeons were exposed to continuous punishment in one stimulus and first response punishment in the other. It was found that continuous punishment suppressed the fixed-ratio performance more than did punishment of the first response. Typically, a ratio run of responses was completed in spite of the onset of continuous punishment. Responding was then reduced for the remainder of the continuous punishment stimulus, except for those times when responding was initiated near the end of the stimulus. The results indicate that a multiple schedule can be used to compare different schedules of punishment in the same organism.

Although punishment has been studied in various experiments during the past 50 years, a functional analysis of the effects of punishment on behavior has only recently been attempted. Once it was established that the aversive stimulus must be programmed contingent upon a response to suppress behavior (Azrin, 1956), the interaction between punishment and reinforcement schedules was investigated. When continuous punishment is introduced upon variable-interval or fixed-interval schedules of reinforcement, a general overall suppression occurs in the frequency of responding (Azrin, 1960; Azrin and Holz, 1961). However, continuous punishment programmed concurrently with fixed-ratio and differential-reinforcement-of-low-rate reinforcement schedules produced selective effects; in the former case, the post reinforcement pause increased while in the latter, the number of inter-response-times not sufficient to obtain reinforcement was reduced. All schedules showed response rate recovery within an experimental session when intensities were mild or moderate (Azrin, 1959b, 1960; Azrin and Holz, 1961).

¹This paper is based on a dissertation submitted to the graduate school of Florida State University in partial fulfillment of the requirements for the Ph.D. degree. The investigation was supported in part by Public Health Service Research Grant MH 07217-02 and in part by the Research Council, Florida State University. The author expresses her appreciation to Dr. A. J. Brownstein. Reprints may be obtained from the author, Psychology Dept., University of Missouri, 5100 Rockhill Road, Kansas City, Missouri 64110.

Once punishment was removed, the rate of responding often exceeded the pre-punishment rate.

Consideration of different schedules of punishment is important to an analysis of the aversive control of behavior. Recently Dardano and Sauerbrunn (1964) introduced a fixed-ratio schedule of punishment upon a fixed-ratio schedule of reinforcement. When electric shock was contingent upon the first response of the ratio, a selective effect occurred in the increased duration of the post reinforcement pause similar to that reported by Azrin (1959b). Since Azrin (1959b), using intermittent punishment, reported comparable effects, a direct comparison of these two punishment procedures programmed in the same organism would explicate the functional equivalence of the two punishment schedules. The present study attempted to make an intra-organism comparison of continuous and intermittent schedules of punishment.

METHOD

Subjects

Six White Carneaux pigeons were each maintained at 80 per cent of free-feeding weight throughout the experiment.

Apparatus

A Lehigh Valley Model 1519C pigeon box served as the experimental chamber. A response consisted of a peck against a translucent

key sufficient to close a microswitch. Mixed grain served as the reinforcer and was presented for 2 or 3 sec, depending upon the subject. House light and key light illumination were present except when the grain was available. A relay click provided response feedback after each peck of the response key. White noise masked extraneous sounds.

Punishment was a 60 cps shock delivered through 10,000 ohms in series with the bird for a duration of 50 msec. Using a procedure developed by Azrin (1959a), the shock was delivered through electrodes implanted around the pubis bone. All experimental manipulations were programmed through electro-mechanical switches, timers and counters.

Procedure

Multi-element baselines of fixed-ratio 40 or 50—that is, for every 40th or 50th response a reinforcer was delivered—were used to establish steady responding. Red and green lights alternated every 2 min on the translucent key, which served as the response mechanism. The same fixed-ratio schedule of reinforcement was programmed during each key color. When shock was introduced, the key color served as a discriminative stimulus for the punishment contingency. Each session lasted 28 min, thus

permitting seven exposures to each ply. A reinforcer was delivered after the first key peck in each session.

Once steady responding under fixed-ratio reinforcement had been established, two birds were exposed immediately to a multiple punishment schedule which provided continuous punishment in one color and punishment of the first response of each ratio in the other. Two birds were first exposed to punishment of the first response of each ratio in both plies before the multiple punishment schedule was introduced. Two birds were first exposed to continuous punishment in both plies before being exposed to the multiple punishment schedule. Punishment was then removed from both plies of the multiple schedule for all birds. Punishment intensity was always the same in both plies.

RESULTS

The first two panels of Fig. 1 show that when moderate intensity punishment (20-40 v) was introduced after the first response of each ratio, the rate changed little. Similarly, the first two frames of Fig. 2 shows that when punishment of comparable intensities followed each response, little suppression in rate occurred.

Fig. 1. Responses per minute during the last 24 min of each session over conditions of baseline, punishment of the first response of each ratio, differential punishment, and recovery for P-71 and P-90. Duration of hopper presentation is not included in the rate measures.

Fig. 2. Responses per minute during the last 24 min of each session over conditions of baseline, continuous punishment, differential punishment, and recovery for P-73 and P-91. Duration of hopper presentation is not included in rate measures.

The first two sections of Fig. 3 present cumulative records of typical sessions from the baseline and first response punishment conditions for P-71 and P-90. First response punishment produced little change in rate but did occasionally increase the post reinforcement pause. These increases in pausing are more pronounced in the record of P-90. The first two sections of Fig. 4 provide cumulative records from typical sessions of the continuous punishment and baseline conditions. Response rate declined during the initial minutes of each session of P-73 when continuous punishment was programmed, but no change from baseline rates was apparent for P-91 at 40 v. Continuous punishment slightly increased the post reinforcement pause for P-73.

The third panel of Fig. 1 shows the changes in response rate when punishment in one component was switched from first response punishment to continuous punishment while first response punishment was maintained in the other. The rate did not change in the unchanged component, but continuous punishment immediately suppressed rate.

When the punishment contingency was changed from continuous punishment to the

multiple punishment schedule (third panel of Fig. 2) little or no suppression occurred in the continuous punishment ply. For P-73 responding in both plies of the multiple schedule showed little change from either no punishment or continuous punishment alone. Initially, the continuous ply of the multiple schedule maintained the rate previously under continuous punishment alone, while the rate in the first response punishment ply was accelerated. By the 21st day however, both rates were essentially the same. Examination of the data for P-91 in Fig. 2 when the multiple punishment schedule was introduced indicates that greater suppression occurred in first response punishment than in continuous punishment up to 70 v. This bird had a history of continuous punishment before the data presented here were collected. This may have attenuated the suppressive effects of continuous punishment.

Immediate exposure to the multiple punishment schedule following baseline produced very little suppression at 20 v. Figure 5 presents the day-to-day rate changes as a function of different intensities programmed in the multiple punishment schedule. At 30 v, substantial suppression had occurred in the continuous pun-

Fig. 3. Cumulative records of responding during baseline, punishment of the first response, differential punishment and recovery for P-71 and P-90. Beginning with punishment of the first response, the recorder pen reset with the onset of each new stimulus condition. During differential punishment, P-71 was exposed to continuous punishment in the first stimulus condition and punishment of the first response during the second. The order was reversed for P-90.

Fig. 4. Cumulative records of responding during baseline, continuous punishment, differential punishment, and recovery for P-73 and P-91. Beginning with continuous punishment, the recorder pen reset with the onset of each new stimulus condition. During differential punishment, P-73 was exposed to continuous punishment in the first stimulus condition and punishment of the first response during the second. The order was reversed for P-91. P-91's record during the multiple punishment was taken at 70 v.

ishment ply for P-52 and complete suppression for P-69. Intersession recovery was evident after several exposures to punishment at the same intensity in both birds up to the 13th day at 40 v. Following a correction of the apparatus on the 13th day of multiple punishment, P-52 did not show intersession recovery while punishment was maintained. Rates under first response punishment were also suppressed. Over the course of exposure to punishment at 40 v, rates for P-69 during the continuous punishment ply fluctuated between zero and 190 responses per min, finally stabilizing with partial suppression.

The third panel of Fig. 3 and 4 and the second panel of Fig. 6 show the temporal pattern of suppression during the multiple punishment schedule. As noted above, responding was less during the continuous punishment stimulus. A common characteristic of all subjects was that if responding was initiated at the end of the first response stimulus, the ratio was typically completed without disruption by the onset of the continuous punishment period. A

lower rate of responding then occurred during the remainder of the period and resumed when first response punishment was next presented. Note in addition the increased pausing in the first response punishment ply immediately before onset of continuous punishment. All subjects initiated responding before first response punishment ply and increased pausing before the continuous punishment ply. P-73's record illustrates the typical intra-session recovery under conditions of the multiple schedule of punishment.

Once punishment was eliminated, recovery was immediate for all subjects. Two subjects, P-52 and P-91, showed some differential responding upon removal of punishment, but generally, responding returned to the original level. These data are presented in the last panel of Fig. 1-6.

Two behavioral effects were characteristic of all subjects as a function of the alternating 2-min periods of each ply. Increased pausing in the first response punishment condition usually occurred immediately before onset of con-

Fig. 5. Responses per minute during the last 24 min of each session for conditions of baseline, differential punishment, and recovery for P-52 and P-69. Duration of hopper presentation is not included in the rate measures.

Fig. 6. Cumulative records of responding during baseline, differential punishment, and recovery for P-52 and P-69. Beginning with differential punishment, the recorder pen reset with the onset of each new stimulus condition. During differential punishment, P-52 was exposed to continuous punishment in the first stimulus condition and punishment of the first response during the second. The order was reversed for P-69.

tinuous punishment. Similarly, responding initiating just before first response punishment often occurred during continuous punishment. To explicate these effects, the duration of the continuous punishment ply was varied from 1 to 3 min in one subject (P-71). The first response punishment condition remained 2 min in duration.

When continuous punishment was in effect for 1 min, no responding occurred except that necessary to complete an on-going ratio. Figure 7 is a typical cumulative record. If the ratio was interrupted before seven-tenths of the requirement was emitted, the introduction of continuous punishment suppressed responding. When the next cycle of first response punishment was presented, the ratio was then completed.

When continuous punishment was increased to 2 or 3 min, ratios interrupted by the occurrence of continuous punishment were typically completed. This is apparent in the cumulative records in Fig. 7. As the duration of continuous punishment was increased from 2 to 3 min, initiation of responding, if it occurred at all, took place toward the end of a 2-min period. This is illustrated in segments 2, 8, 10, and 12 of the 3-min alternation in Fig. 7. If the discriminative stimulus for first response punishment did not occur, the ratio was not completed.

Visual observations indicated that while key pecking behavior was suppressed, the animal stood away from the key and made head and neck movements toward it. Occasionally these movements would make contact with the key and produce the punishment. When this occurred, the bird stepped back and began to engage in the same ritualistic behavior. Other behaviors observed included standing in a far corner facing the opposite direction of the key.

DISCUSSION

The effect of punishing each response in fixed-ratio behavior has been reported by Azrin (1959b) to be an increase in the pause following reinforcement. With intensities up to 80 v, post reinforcement pausing increased only during the initial minutes of each session. As the session progressed, typical fixed-ratio behavior was observed in spite of the maintenance of the punishment contingency. As the intensity increased beyond 80 v, increased pausing occurred throughout the session. Local rate was unchanged at any intensity programmed. When moderate punishment followed each response in the present study, the data show increased post reinforcement pausing during the first few minutes with recovery

Fig. 7. Cumulative responding during varying durations of continuous punishment condition while the condition for punishment of the first response was held constant for 2 min. Each record is from the same subject, and punishment is 70 v.

of baseline rates by the end of each session. These results agree with those of Azrin (1959b).

Dardano and Sauerbrunn (1964) reported the effects of selectively punishing responses in fixed-ratio behavior. When the electric shock was made contingent upon the first response in each ratio, one of the effects was prolonged pauses after reinforcement. This occurred under intense punishment. In the present study, exposure to punishment of the first response at mild intensities (20 to 40 v) produced little change in total rate. These differences in results could be attributed to the differences in intensities, since much higher intensities were necessary to produce consistent decreases in total rate in the pigeon (Dardano and Sauerbrunn, 1964).

Intra-subject comparisons between continuous punishment and punishment of the first

response indicated that continuous punishment is much more effective in suppressing behavior than is punishment of the first response of each ratio. This was true in all the subjects except P-91 whose behavior below 70 v is not clear.

The usefulness of a multiple schedule is determined by maintenance of control over the behavior generated in the presence of each discriminative stimulus. Because stimuli are often programmed arbitrarily in reference to behavior, the relationship between stimulus introduction and on-going behavior creates opportunities for adventitious correlations to occur which obscure stimulus control. In the present study, the appearance of longer pauses near the end of the first response punishment ply and initiation of responding near the end of continuous punishment, indicated that these two behaviors may have resulted from their adventitious correlations with the stimuli of the next programmed punishment condition.

A second feature of multiple schedules involves interactions between the rates of responding generated in each ply. Reynolds (1961) defined such a change as behavioral contrast. If animals are conditioned on a multiple schedule with the same variable-interval schedule of reinforcement in each ply, and then one of the plies is changed to extinction, the decrease in response rate during the unreinforced component is accompanied by an increased rate during the reinforced component. Similar results were reported by Brethower and Reynolds (1962) when rates of responding were found to increase in the unpunished component as a function of the decrease in rate during the punished one. Several factors, such as a change in response topography, adventitious contingencies related to successive presentation of stimuli, and addition of a punishment contingency to both components, may explain the absence of contrast in the present data.

A common reaction to the punishment situation is intrasession recovery during maintenance of the punishment contingency (Azrin, 1960, Azrin, Holz, and Hake, 1963). Azrin *et al.* (1963) concluded that this warm-up effect was a general reaction to a situation involving aversive stimulation. When the differential punishment procedure was introduced, responding typically began in the less aversive

component. Intrasession recovery was present in all the subjects whenever suppression was observed.

REFERENCES

- Azrin, N. H. Some effects of two intermittent schedules of immediate and non-immediate punishment. *J. Psychol.*, 1956, **42**, 3-21.
- Azrin, N. H. A technique for delivering shock to pigeons. *J. exp. Anal. Behav.*, 1959, **2**, 161-163, (a).
- Azrin, N. H. Punishment and recovery during fixed-ratio performance. *J. exp. Anal. Behav.*, 1959, **2**, 301-305. (b)
- Azrin, N. H. Effects of punishment intensity during variable-interval reinforcement. *J. exp. Anal. Behav.*, 1960, **3**, 123-142.
- Azrin, N. H. and Holz, W. C. Punishment during fixed-interval reinforcement. *J. exp. Anal. Behav.*, 1961, **4**, 343-347.
- Azrin, N. H., Holz, W. C., and Hake, D. F. Fixed-ratio punishment. *J. exp. Anal. Behav.*, 1963, **6**, 141-148.
- Brethower, D. M. and Reynolds, G. S. A facilitative effect of punishment on unpunished behavior. *J. exp. Anal. Behav.*, 1962, **5**, 191-199.
- Dardano, J. F. and Sauerbrunn, D. Selective punishment of fixed-ratio behavior. *J. exp. Anal. Behav.*, 1964, **7**, 255-260.
- Holz, W. C., Azrin, N. H., and Ulrich, R. E. Punishment of temporally spaced responding. *J. exp. Anal. Behav.*, 1963, **6**, 115-122.
- Reynolds, G. S. Behavioral contrast. *J. exp. Anal. Behav.*, 1961, **4**, 57-71.

Received April 29, 1965