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Amount of prior learning, density of reinforcement and "vacation" from punishment as determinants of punishment effectiveness: Some negative results

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Some relations between positive reinforcement and punishment effectiveness were explored in three studies employing shock punishment of food-motivated leverpressing. Amount of prepunishment training on a variable-interval schedule of reinforcement was varied over 7, 21, 35, 49, and 63 h and was found to be unrelated to magnitude of suppression produced by shock punishment. A second study found no relationship between density of reinforcement delivered on a variable-interval schedule during prepunishment training and subsequent response suppression. In a third study, alternating cycles of punishment/no punishment (vacation from punishment) eventually resulted in a lessening of the initial disruptive effects of punishment, although contrary to previous reports, successive vacations did not enhance the suppressive effects of punishment.

The bulk of research on punishment has concentrated on the study of behaviors established by positive reinforcement. Therefore, it is not surprising that many investigators have been concerned with the question of how punishment interacts with variables supporting the maintenance of the punished behavior. The purpose of the present paper is to report on the influence of three such variables: the amount of prepunishment training, the density of the reinforcement schedule supporting the punished response, and the alternation of periods of punishment and withdrawal of punishment (vacation from punishment). The reason these three particular variables were chosen for study is that they so often play a part in the apparently arbitrary selection of baseline parameters used in studies of the punishment of learned instrumental behaviors. Additionally, as indicated in the text of this paper, there is some evidence indicating that each of these variables may influence the outcome of any given punishment procedure.

EXPERIMENT 1

The initial study investigated whether the strength of learning, as manipulated by the number of prepunishment positive reinforcement training sessions, influences the amount of response suppression produced by punishment. Both intuitively and in terms of a small amount of empirical evidence on overlearning, it may be expected that increases in strength of the prepunished behavior would lessen the disruptive effects of punishment. However, there is some evidence that rats given discrete trial training in an alleyway show greater disruption of approach behavior if they have been "overtrained" prior to the introduction of punishment (Karsh, 1962; Miller, 1960).

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Method

Subjects. Fifteen male hooded rats, 90-120 days of age, were maintained at 80% of their free-feeding weight. All animals were experimentally naive at the start of the experiment.

Apparatus. Two standard Grason-Stadler experimental chambers (E3125B) with one lever removed were used for testing. The reinforcer was a 45-mg Noyes pellet, and scrambled shock, derived from Grason-Stadler E1064GS generators, was delivered through the grid floor of the chambers. All programming and data recording equipment were housed in a separate room from the experimental chamber.

Procedure. Following a single day of magazine training, subjects were allowed to press the lever to receive food on a continuous reinforcement schedule (CRF) until 100 pellets had been obtained; each rat received 10 CRF sessions. Following this, all animlas were placed directly on a variable-interval 1-min (VI 1-min) reinforcement schedule. Sessions were each 1 h long and were run 7 days a week. The animals differed only in the number of VI acquisition sessions allowed: 7, 21, 35, 49, or 63 sessions. Upon reaching the appropriate number of acquisition sessions, a response-contingent punishment procedure was superimposed upon the VI schedule. Now, every leverpress was accompanied by a .20-mA shock of 100 msec duration. A total of 45 punishment sessions were given.

Results and Discussion

A suppression ratio, B/A + B, was computed, where B = mean number of responses per minute during the first 7 days of punishment and A = mean responses per minute during the first 7 days of prepunishment training. Thus, the lower the ratio value, the greater were the

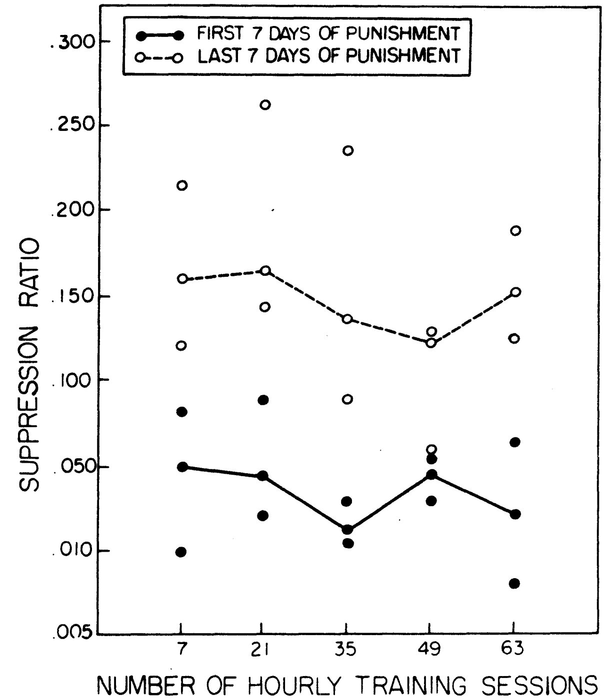

Figure 1. Suppression ratio as a function of number of prepunishment sessions for individual animals. Lines connect the median animal under each condition.

suppressive effects of punishment. The choice of prepunishment training days used in this computation was made in order to equalize for training effects among the five different periods of training. A similar ratio utilizing the prepunishment rates for the final 7 days of training was also calculated for all groups, and the resulting functions were not found to differ appreciably from those shown in Figure 1. As can be seen from this figure, the amount of prepunishment training did not modify the response-reductive effect of punishment; the responding of animals that had received 63 h of training was suppressed to the same degree as those receiving only 7 h. Figure 1 also shows that the punished response recovered somewhat over the punishment period, as indicated by the higher suppression ratios yielded over the final 7 days of punishment. Finally, no differences were found in the rate of recovery among groups upon removal of the punishment contingency.

EXPERIMENT 2

The second experiment examined the effects of reinforcement density during prepunishment training on subsequent response suppression. The basic procedures were the same as in Experiment 1, except that in this study all animals received an equal number of prepunishment sessions and differed only in terms of the number of reinforcers received during each fixed-time daily session (i.e., the density of reinforcement).

Method

Subjects and Apparatus. Seven hooded rats, 90-120 days old, maintained at 80% of normal weight were used. The apparatus was identical to that used in Experiment 1.

Procedure. Preliminary training was identical to that described for Experiment 1, except that the animals received between 40 and 42 1-h sessions of VI prepunishment training under different conditions of reinforcement density. Animals were trained under VI 15-sec (Rats R4 and R12), VI 1-min (R6 and R9), VI 2-min (R14), or VI 4-min (R5 and R11).

Following the last day of prepunishment training, punishment was instituted such that all leverpresses made during a session were accompanied by an electric shock. The punishment procedure and parameters were identical to those described in Experiment 1. The punishment contingency was in effect for a minimum of 40 sessions.

Results and Discussion

Figure 2 shows the mean rate per minute during the prepunishment and punishment conditions for rats trained under the four different densities of reinforcement. Data for this figure are based upon mean rates for the last 5 days of prepunishment training and the last 5 days of punishment. During training, as density of reinforcement decreased, the function relating response rate to schedule density declined. The rate-density function during punishment, shown in Figure 2, was different from the rate-density prepunishment function. A drop in rate occurred when reinforcement density shifted from the two most dense (VI 15 sec and

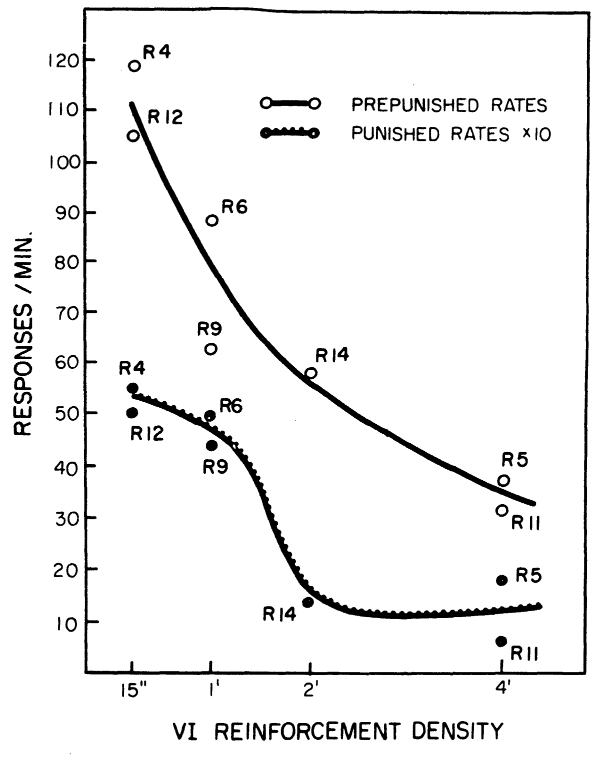

Figure 2. Response rate during prepunishment and punishment conditions as a function of reinforcement density on a VI schedule.

VI 1 min) to the two least dense values (VI 2 min and VI 4 min).

In order to compare the relative magnitude of response suppression produced by punishment of animals differing in reinforcement density, suppression ratios were calculated using the same data described in Figure 2. The ratios for the four density values were VI 15 sec = .05; VI 1 min = .06, VI 4 min = .02, and VI 4 min = .03. Although these data tend to support the findings obtained using absolute response rates, the overall rate of response during punishment was very low (see Figure 2), and the ratio values fall within a very narrow range. Therefore, when relative response rates are considered, differences in reinforcement density do not significantly modify the effectiveness of the punishment procedure employed. Similar findings involving the punishment of behavior maintained by multiple variable-interval schedules have been previously reported (Tullis & Walters, 1968).

EXPERIMENT 3

The final experiment was concerned with changes in punished behavior resulting from repeated exposure to alternating cycles of punishment/no punishment. Procedurally, such "vacations" from punishment may simply involve the removal of the subject from the testing situation for a period of time, or the subject may continue in the test situation with the punishment contingency removed while positive reinforcement remains in effect. In either case, the vacation is followed by a reintroduction of punishment at some later time. Although it might seem that punished behavior would gain strength during a vacation from punishment, the results of simple removal (Azrin, 1959, 1960; Masserman, 1946; Orme-Johnson, 1967) or of positively reinforced nonpunished vacations (Azrin, 1960; Brethower & Reynolds, 1962; Masserman, 1946; Rachlin, 1966), indicate that, in general, the reintroduction of punishment suppresses behavior as much or more than the initial exposure to punishment. In fact, Rachlin (1966) has argued that prior experience with punishment increases the instrumental suppressive power of the punishing stimulus. Thus, the recovery of response rate often observed over repeated punishment sessions is viewed as a transient phenomenon; that is, it is recovery and not suppression of the punished response which drops out with successive cycles of punishment/no punishment. However, Orme-Johnson (1967) found that, while a vacation from punishment did increase the suppressive effects of punishment, successive vacations resulted in a *diminution* of this effect. Orme-Johnson studied nonreinforced vacations, while Rachlin's studies employed reinforced vacations involving the removal of the punishing stimulus while the animal continued working in the test situation. The present study involved the use of reinforced vacations over five cycles, in order to assess the stability of vacation effects over repeated and prolonged reinforced vacation periods.

Method

Subjects and Apparatus. Two hooded rats (G5 and G6), 90-120 days of age, were maintained at 80% of their free-feeding weight. The apparatus was identical to that used in Experiments 1 and 2.

Procedure. Following preliminary training (as described in Experiment 1), both animals were given 14 daily 1-h sessions of VI 1-min prepunishment training. Upon completion of the original VI training, a response-contingent punishment procedure was introduced, in which all leverpresses were accompanied by shock. The values of the punishing stimulus and general details of the punishment procedure were identical to those described in Experiment 1.

Upon completion of the original 14-day prepunishment period, punishment was introduced for a period of either 9 or 10 sessions, after which the animals were placed on vacation for 18 sessions. A vacation consisted of removing the punishment contingency during the testing sessions; vacation was followed by a reintroduction of punishment. A total of five vacation-punishment cycles was given during the experiment, including the original prepunishment sessions. On any given cycle, animals remained on punishment or on vacation until their response rates stabilized.

Results and Discussion

Following the introduction of puishment, both animals showed a marked suppression of leverpressing with a concomitant loss in reinforcers. Both response rate and reinforcement rate increased to a stable but lower than prepunishment level after several days. Response rate remained at a low level throughout the operation of the punishment contingency. Both animals showed less disruption of both response and reinforcement rate during the initial punishment sessions of each successive punishment cycle as the number of such cycles increased; by the third cycle, both rates showed considerably less disruption than during the first two cycles. A substantial loss of reinforcement was still apparent in Animal G5 during the first eight sessions of the third punishment cycle. Neither animal consistently obtained the maximum of 60 reinforcements during any of the punishment sessions over the five cycles; reinforcers continued to be lost during punishment to a greater extent than during nonpunishment portions of the cycle. There was no evidence of an instrumental effect of punishment over the punishment components such as reported by Rachlin (1966). However, there was a gradual decline in responding over successive cycles during the nonpunished component of each cycle. By the fifth and final cycle, both rats were responding at a rate more closely approximating their original prepunishment rate than during any of the previous cycles.

GENERAL DISCUSSION

The three variables studied, amount of prepunishment training, density of reinforcement, and vacation from punishment, were found to have little if any effect on punished behavior.

With respect to amount of prepunishment training, Miller (1960) referred to a "paradoxical overtraining effect" in one of his studies investigating punishment of rats trained to traverse in alleyway and enter a goalbox for food reinforcement. He noted that rats that had been overtrained (defined as having undergone a number of additional discrete trials after achieving asymptotic performance as measured by alleyway running speeds) were less resistant to the disruptive effects of punishment than were control rats that were punished as soon as performance became stable. Karsh (1962), using similar performance measures, also found an indication of this overtraining effect, although she noted that it was not a robust phenomenon. More representative of the bulk of contemporary research on punishment in which free-operant intermittent reinforcement is used is the study by Estes (1944, Experiment F). He reported that, during extinction, punished rats that had been trained for 5 h resisted the suppressive effects of punishment more than rats that had been trained for only 1 h, a finding that is opposite those of Miller and Karsh. Certainly, the present study supports neither of these general findings, in that no relationship was found between the number of prepunishment training sessions and punishment effectiveness over a wide variety of training sessions. Whether procedural and parametric variations would have yielded different results is an empirical question. However, the findings of Experiment 1 are not consistent with Church's (1963) general statement that "the effectiveness of punishment typically is inversely related to the strength of the response that is punished." To the extent that response strength can be manipulated by the amount of prepunishment training, Church's statement must be qualified.

The results of the second study, dealing with positive reinforcement density and punishment, indicated that VI schedule density did not have a pronounced effect on the degree of suppression during punishment. Although prepunishment responding on the VI schedules showed an orderly decline as reinforcement density decreased, the relative response rate during punishment was virtually unaffected. This is contrary to results reported by Church and Raymond (1967), who found that the effectiveness of punishment was inversely related to the rate of positive reinforcement. The present findings, however, are consistent with a previous study using multiple schedules of reinforcement (Tullis & Walters, 1968), as well as that of Holz (1968), who found the effectiveness of punishment to be unrelated to the rate of positive reinforcement. There are methodological differences between the Church and Raymond study and the present study; whereas Church and Raymond delivered punishment on a VI 2-min schedule, the present study punished all responses emitted during testing sessions. Furthermore, Church and Raymond gave their subjects only five 1-h training sessions, while the rats in the present study received 40 to 42 such sessions, and those in the Tullis and Walters (1968) study received 65 90-min sessions. The response rates of Church and Raymond's high-density group showed a steady increase over training sessions and did not appear to have reached a stable level when punishment was introduced. The suggestion is that prepunishment rates for their animals may have been artificially low, thus inflating the suppression ratio calculated during punishment.

Finally, the effects of a vacation from punishment on response suppression and recovery indicated that the initial exposure to punishment had a greater disruptive effect upon response rate than following a series of vacations during which the punishment contingency was removed and the reinforcement contingency remained. Successive vacations resulted in some diminution of the initial suppressive effects of punishment. This study did not find that time away from punishment resulted in a greater punishment effect (e.g., Azrin & Holz, 1966), and there was no indication of an instrumental effect of punishment occurring over vacation cycles (Rachlin, 1966), although a tendency was seen for nonpunished responding to decrease over several cycles.

It could be argued that the present findings were a function of the particular parameters chosen for study. Perhaps other reinforcement and punishment schedules would have yielded different results. Variable-interval schedules of reinforcement were specifically selected because they are frequently used in punishment research to establish baselines of stable behavior prior to the study of some punishment variable. Therefore, information about this schedule was considered to be especially significant in the context of punishment research. Whether a different punishment schedule would have yielded different results is an empirical question. However, it seems likely that this would only be the case if the punishment procedure employed in the present series of studies was so severe as to mask any potential effects. Inspection of the absolute response rates for the three experiments indicated that this was not the case; an appreciable degree of responding was maintained through the punishment sessions for all rats.

Thus, while the present findngs may be characterized as "negative results" in the narrow sense that the three positive reinforcement variables studies were not found to exert powerful effects on punishment-produced suppression, this information is itself of value to researchers studying punishment and also stands in contrast to some earlier reports suggesting that there may be some general relationships between these reinforcement variables and punishment effectiveness.

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