# Reports

## Changes in Intensity of Punishment: Effect on Running Behavior of Rats

Abstract. *Changing the strength of punishment produced only minor changes in rats' speed of running to food and shock at the goal of an alley. The persistence of running behavior after increased or decreased shock intensity is attributed to a stereotyped withdrawal response conditioned at the goal during initial punishment training.*

Earlier research concerning the effects of punishment of a learned response showed that electric shock given late in training had a more disruptive effect upon that response than shock introduced earlier in the learning process (*1, 2*). These results seemed paradoxical, since increased training theoretically adds to habit strength and thus is expected to reduce the effect of the punishment. However, it appeared that because the stimulus situation became better established with more trials, the introduction of shock caused a greater change, which in turn weakened the strength of the goal-approaching response. If the disruptive effect of strong punishment is thus partly due to the novelty which it brings into the situation, persistence of running behavior during strong punishment should be increased by prior training with weak punishment and reward, as opposed to training with reward alone. Miller found that a series of shocks which gradually increased from weak to strong was less disruptive than a suddenly introduced strong shock (*1*). The first experiment in the present study investigated the effectiveness of training with mild shock (which causes only a small decrease in responding) in preserving the learned response when it was later strongly punished.

Adult male rats were trained to run down an 8-foot straight alley to get a food pellet (0.3 g of wet mash) at the goal. Running time from start-box to food cup was automatically recorded, and a reciprocal transformation provided speed scores. On punished trials, a 0.1-second, 60-cy, a-c shock was delivered to the animal's feet through the grid floor (with a 250-kohm, current-limiting resistor in series with the rat) as the rat touched the moist pellet in the food cup (*2*). Subjects were given one trial daily, after 23½ hours' food deprivation, throughout the experiment. The experimental group (36 rats) received an average of 40 training trials with food, followed by 100 trials with food and a weak shock (120 volts). This caused them to slow down and then stabilize their approach at a speed about 15 percent lower than that of the control group. The 12 control animals were given 140 trials with food and no shock. After this, both groups received food and strong shock (200 volts) for 30 trials. Figure 1 shows that the speed of the control group dropped sharply for the first 15 trials and then leveled off at a very low rate. The experimental group started at a speed reliably lower than that of the control group, but the experimental group's speed decreased more gradually and remained well above that of the control group after the first five trials with strong shock. An analysis of variance showed that the differential decline was significant ($F = 18.41$; $df = 6, 276$; $p < .001$). Some of the animals stopped running, that is, failed to reach the goal within a 5-minute period. These animals were removed without being shocked and were given speed scores of zero. During the last five strong-shock trials, more than half of the control animals but only one-third of the experimental rats had stopped running. Thus, training with relatively mild punishment, which slightly depressed responding, resulted in persistence of running behavior when stronger punishment was applied. This persistent running was not due to adaptation to the punishing effects of mild shock, since the experimental group did not increase their running speed to the level of the control group during the trials with weak shock.

The slow, gradual decrease in responding shown when the subjects were changed from weak to strong shock contrasts with previous data showing rapid shifts in performance with both increases and decreases in amount of reinforcement. These earlier studies showed complete shifts within 15 trials when the amount of food at the goal was changed (*3*) and also when the amount of shock reduction was changed for animals running to escape shock (*4*).

To complete the comparison between changes in amount of reinforcement and changes in amount of punishment, it was necessary to determine the effect of *decreasing* shock intensity. Consequently, the second experiment varied shock intensity in both directions (strong to weak and weak to strong). Sixty rats, randomly divided into five groups of 12 each, were trained to run down the alley for food, as in the first experiment. Five to ten training trials were given.

After training, three of the five groups received 50 trials with food and strong shock (200 volts). A final shock period consisting of 30 additional trials was given to these three groups as follows: one group was maintained at the same intensity, the second group was shifted to a weaker shock (120 volts), and the third group was changed to no shock.

The other two of the five groups received 50 trials with food and mild shock (120 volts). During the final shock period, one of these groups received the 30 additional trials at the same shock level, while the second group had these last 30 trials at a stronger shock level (200 volts).

During the first 50 trials, all five groups reached and maintained stable levels of speed commensurate with the amount of shock given. The two weak-shock groups were running at about 3½ feet per second, significantly faster than the three strong-shock groups, which all averaged about 2 feet per second. ($F = 25.93$; $df = 1, 55$; $p < .001$). Animals given strong shock did not stop running, as did the rats in the first experiment. Instead, they ran slowly down the alley and hesitated in the goal area before touching the food cup (*5*).

During the final shock period of 30

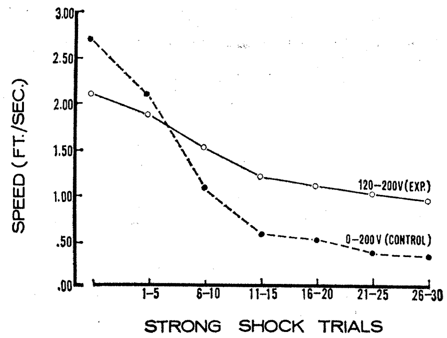


Fig. 1. Effect of strong shock (200 volts) on the running speed of rats after training with weak shock (120 volts) or no shock.

trials, shown in Fig. 2, the two control groups—those that received the *same* shock as on the first 50 trials (120 or 200 volts, respectively)—maintained fairly stable speeds, as expected. The group that was changed from weak to strong shock (from 120 to 200 volts) decreased its speed gradually below its control group (shock maintained at 120 volts), but still ran much faster than the group that received 200-volt shock in both sets of trials. Similarly, the rats shifted from strong to weak shock gradually increased their speed, but did not reach the speed of the rats that received a weak shock in the first 50 trials. The change from strong to no shock caused a greater increase during the final 30 shock trials than the shift from strong to weak shock ($F = 3.95$; $df = 6, 132$; $p < .005$).

An analysis of variance performed on the scores for the final 10 shock trials showed that both groups which received changes in shock intensity (120 to 200 volts, or vice versa) altered their speed reliably compared to their respective control groups maintained at constant shock intensity ($F = 4.49$; $df = 1, 44$; $p < .01$). However, the group that was switched from 120 to 200 volts still ran significantly faster than the group that had been maintained at 200 volts; and the group switched from 200 to 120 volts, significantly slower than the group maintained at 120 volts ($F = 8.99$; $df = 1, 44$; $p < .001$). In fact, the change in shock caused these two groups to approach a level midway between the speeds of the two unchanged controls ($F < 1$). Thus, running speed after a change in shock intensity was determined by both present and previous shock experience, with the initial experience appearing to be the more potent factor.

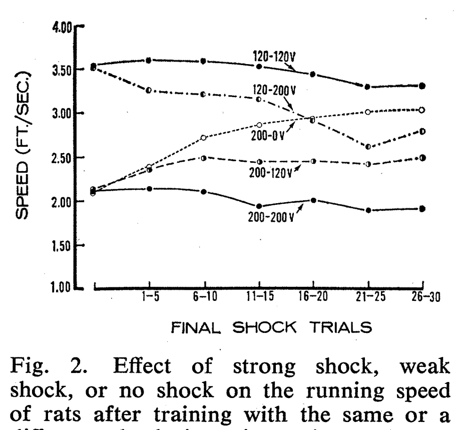


Fig. 2. Effect of strong shock, weak shock, or no shock on the running speed of rats after training with the same or a different shock intensity. Figures before the hyphens indicate shock voltage given in 50 preliminary trials. Figures after the hyphens show voltage in 30 subsequent trials.

The results clearly indicate that changes in the intensity of punishment, regardless of the direction, produce gradual, "incomplete" shifts in running speed. It is important to note that these gradual shifts in speed were accompanied by an observed response stereotypy after shock at the goal. Typically, animals receiving weak shock at the food cup shudder or lurch backward slightly, while rats getting strong shock jump back from the food cup more violently. Animals given a change in shock intensity exhibited approximately the same response to shock as observed prior to the change. That is, rats getting a weak shock after experience with a stronger one continued to jump back after the weak shock just as they had jumped after the strong one. However, rats getting strong shock after weak shock never jumped very hard. The amount of change in running speed when shock intensity is shifted appears to be strongly influenced by the response stereotypy developed during initial shock training.

The withdrawing response to shock is associated with two reinforcing events, shock termination and eating, and thus apparently becomes strongly conditioned to the goal cues. Changing the strength of shock does not produce an immediate change in the strongly conditioned withdrawal response and this could account for the gradual, incomplete shift in running speed. During the first punished trials the withdrawal response tends to become anticipatory, that is, incipient withdrawal responses occur progressively nearer to the beginning of the alley, with the result that the rats run more slowly when punished than before. Running speed during punished trials depends on the strength of the withdrawal response—the stronger the initial punishment, the stronger the withdrawal response and the slower the speed. However, when intensity of punishment is changed, the withdrawal response does not change and running speed also resists change because it reflects the strength of the withdrawal response. The development of such a persistent withdrawal response at the goal is characteristic of the punishment situation and distinguishes it from learning with reward alone (*6*).

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### References and Notes

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4. G. H. Bower, H. Fowler, M. A. Trapold, *J. Exptl. Psychol.* **58**, 482 (1959). Both shock *reduction* and food presentation are reinforcing events which strengthen responses associated with them. However, the *presentation* of a noxious stimulus like shock is a punishing circumstance which may inhibit the response producing the punishment.
5. Rats in the second experiment ran faster both in training and in shock conditions than rats in the first experiment, because of an apparatus improvement which made the food more accessible and reduced the delay in obtaining reward.
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## Dynamic Reflectance Spectroscopy: A New Thermal Technique

Abstract. *Dynamic reflectance spectroscopy, a new thermal technique, measures the change in reflectance of a sample at a fixed wavelength as the temperature of the sample is increased. The technique is illustrated by the thermal dissociation of* $CoBr_2 \cdot 6H_2O$.

Although diffuse reflectance spectroscopy, at room temperature, is an important tool in structural studies on solid coordination compounds (*1*), little work has been done with this technique at elevated temperatures (*2*). Previously, we have described a high temperature sample holder in which the reflectance spectra of solid samples could be determined from ambient temperature to 500°C (*3*). In this tech-