Self-punitive avoidance behavior in the Mongolian gerbil*

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Gerbils were trained to avoid shock by leaving a startbox and traversing a 4-ft alley. During the first 20 extinction trials (Phase 1), one group was given regular extinction. A second group was punished in the middle 2-ft section of the alley. During the last 30 extinction trials (Phase 2), conditions were reversed for the two groups. Punishment increased speeds in the prepunishment region as well as in the entire alley. It also reversed an extinction trend for the group given regular extinction during Phase 1. Furthermore, punishment-induced facilitation was greater when the punishment phase followed regular extinction rather than avoidance training. In general, these results are similar to those obtained with rats under comparable circumstances.

If punishment is administered during the extinction of aversively motivated responses, it may sustain or even enhance behavior. This self-punitive or "vicious circle" phenomenon has been primarily found with shock punishment applied during an ongoing locomotor response. As reviews of the literature (Brown, 1969; Melvin, 1971) indicate, this research has concentrated on the one type of S—the laboratory rat.

Recently, however, Martin, Ragland, & Melvin (1970) obtained the basic vicious circle effect with Mongolian gerbils, using a shock-escape procedure, an immediate location of punishment, and a between-groups design. Relative to vicious circle behavior exhibited by rats under comparable conditions, the effect found was rather "weak." Martin et al recommended higher shock intensity and a shorter, narrower runway for use in future gerbil studies.

We adopted these recommendations in order to maximize vicious circle behavior in gerbils. The generality of this phenomenon was further tested through the use of avoidance training, an intermediate location of punishment, and within-Ss comparisons.

Our experimental design is similar to that used by Melvin & Smith with rats (1967). This "shift" design enabled them (and us) to demonstrate a within-Ss vicious circle effect as well as a progressive increase in speed during punished extinction phases, i.e., the "learning" of self-punitive running.

SUBJECTS

The Ss were 4 female and 10 male

naive gerbils (*Meriones unguiculatus*) with a mean weight of 61.2 g ($s = 6.8$ g) at the beginning of experimentation. All female and 8 male gerbils were obtained from Blue Springs Hatchery (Leeds, Ala.). The remaining 2 males were offspring of two gerbils obtained from a local pet store. They were housed 2 to 4 to a cage with food (Purina Lab Chow) and water available ad lib throughout the experiment.

APPARATUS

The apparatus, described in detail by Melvin, Athey, & Heasley (1965), consisted of a 30.5-cm startbox, a 121.9-cm straight alley, and a goalbox. The startbox and alley had grid floors, white sides, and glass covers, and were identical in width and height; the larger goalbox was wooden and painted black. In addition, a trapdoor, hinged along one edge, 15.2 cm from the grid floor, divided the startbox into upper and lower compartments. A barrier prevented Ss from leaving the upper compartment; a guillotine door at the goalbox entrance prevented retracing.

Photocells, Hunter KlockCounters, and electromechanical programming equipment were used to control CS presentation and shock administration and measure response times to the nearest .01 sec. Prepunishment time was defined as the time from the release of the trapdoor until interruption of a photobeam 30.5 cm into the alley (just before the punishment zone). Alley time was the time from the interruption of a photobeam 1.3 cm into the alley to the interruption of a photobeam 1.3 cm inside the goalbox entrance. The CS throughout the experiment was a 76-dB buzzer. It began as Ss were dropped onto the startbox grid and terminated after 3 sec or when Ss broke the photobeam at the goalbox entrance, whichever occurred first. During avoidance training and punishment extinction, a 130-V pulsed

shock was delivered through a 10 K ohm series resistor.

PROCEDURE

All training and extinction trials were conducted in a single session for each S. The 14 gerbils were assigned randomly to two groups of seven Ss each balanced for sex and source of Ss. The experiment was run in seven replications of two Ss each.

Avoidance Training

Each gerbil was first handled for 5 min prior to its session. Following this, S was placed on the trapdoor in the startbox and allowed to explore the upper compartment for 2 min; each S was then dropped onto the grid floor and allowed to explore the lower compartment, alley, and goalbox for 20 min.

Following exploration, avoidance training was begun immediately. Each S was placed on the trapdoor and dropped on the grid facing the goalbox. The 3-sec buzzer began as the trapdoor dropped and was followed by shock in the startbox and alley. The guillotine door was closed manually as S escaped into the goalbox, where it remained for 30 sec. If S successfully avoided (i.e., reached the goalbox prior to CS offset), the CS was terminated and shock prevented. Training continued until five such consecutive trials were obtained.

Extinction

Immediately following training, Ss received two extinction phases, the first consisting of 20 trials and the second of 30 trials. Group RE-PE received regular extinction during Phase 1 and punishment extinction during Phase 2. Group PE-RE had these conditions reversed, receiving punishment extinction during Phase 1 and regular extinction during Phase 2. During regular extinction, CS termination was no longer followed by shock. Punishment extinction was identical except for the presence of shock in the middle 61.0-cm section of the alley throughout each trial. If S's total response time exceeded 50 sec on any trial, it was removed from the alley and placed in the goalbox for 30 sec. The extinction criterion was three such consecutive trials; however, no S reached this criterion. Other procedural details were constant across training and extinction.

RESULTS

Considerable variability in the number of trials to criterion was exhibited during avoidance training (range = 7-55). There was no significant difference between the mean number of trials to criterion for Groups RE-PE and PE-RE. Also, there were no reliable differences in either prepunishment speed or alley speed during the last training trial.

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Fig. 1. Mean alley speeds for two groups of gerbils during the last trial of avoidance training (T) and successive blocks of five trials during two phases of extinction. Group RE-PE received regular extinction followed by punishment-extinction. Group PE-RE received these conditions in reverse order.

Alley Speed

Median alley speed scores (ft/sec) were obtained for each S for each successive block of five trials during both phases of extinction. Figure 1 displays the alley speed for the two groups for the last training trial and during each phase. As the figure clearly indicates, punishment facilitated avoidance during both phases of extinction.

Phase 1. An analysis of alley speed during Phase 1 revealed significant effects of groups ($F = 17.51$, $df = 1/12$, $p < .01$), blocks of trials, and their interaction ($F = 11.54$, $df = 3/36$, $p < .001$). Tests of the simple main effects of blocks of trials indicated that the extinction trend shown by Group RE-PE was significant ($F = 56.58$, $df = 1/36$, $p < .001$), whereas Group PE-RE exhibited no significant change in speed across Phase 1.

Phase 2. As Fig. 1 indicates, reversal of the treatment conditions drastically modified performance. Shock punishment reversed the extinction trend, and the RE-PE group ran faster than the nonpunished Group PE-RE ($F = 51.50$, $df = 1/12$, $p < .001$). Again, the Groups by Blocks of Trials interaction was significant ($F = 9.54$, $df = 5/60$, $p < .001$), as was the simple main effect of blocks of trials for Group PE-RE.

Within-Ss effects. The deletion or addition of punishment in Phase 2 provided within-Ss comparisons. With the deletion of punishment, the PE-RE group showed progressively slower speed. A t test of the mean decrease

from Block 4, Phase 1, to Block 6, Phase 2, was significant ($t = 9.06$, $p < .001$). A similar test showed that the RE-PE Ss ran faster with the introduction of punishment ($t = 6.98$, $p < .001$). All Ss within a group exhibited similar trends.

Asymptotic self-punitive running. The higher Phase 2 speed of the RE-PE Ss relative to the Phase 1 speed of the PE-RE Ss indicated that punishment following regular extinction led to a stronger self-punitive effect than when punishment followed avoidance training immediately. A comparison of Group PE-RE's speed on Blocks 1-4, Phase 1, with Group RE-PE's speed on Blocks 2-5 of Phase 2 revealed a significant groups effect ($F = 5.04$, $df = 1/12$, $p < .05$). In contrast, a similar analysis over Blocks 1-4 of nonpunished extinction phases yielded only a significant blocks effect.

Learning self-punitive running. In general, the first 18 trials of punished extinction showed progressive increases in alley speed. Thus, analyses were based on means of five blocks of 2 trials, the first block representing the last 2 trials prior to punished extinction. The next four blocks of trials were derived from the initial 8 punishment-extinction trials. The block effect was significant, as was the Groups by Blocks interaction ($F = 14.89$, $df = 4/48$, $p < .001$). This interaction reflects the fact that, while Group RE-PE exhibited a marked and significant increase in alley speed over blocks, Group PE-RE's increase was slight, gradual, and nonsignificant.

Prepunishment Speed

Figure 2 displays mean prepunishment speeds for each group over blocks of trials during each phase, as well as on the last training trial. In

Fig. 2. Mean prepunishment speeds for two groups of gerbils during the last trial of avoidance training (T) and successive blocks of five trials during two phases of extinction. Group RE-PE received regular extinction followed by punishment-extinction. Group PE-RE was given these conditions in reverse order.

general, the results for prepunishment speed were similar to those found with alley speed.

Phase 1. A 2 by 4 analysis of variance yielded only a significant interaction effect ($F = 5.64$, $df = 3/36$, $p < .01$). As the figure shows, this effect is due to the progressive decline in speed for Group RE-PE ($F = 13.22$, $df = 1/36$, $p < .001$), since the punished group exhibited no significant changes in speed over blocks of trials. Due to these different trends, Group PE-RE was running faster than the nonpunished group by the end of Phase 1, i.e., Block 4 ($F = 9.00$, $df = 1/36$, $p < .01$).

Phase 2. Punishment-induced facilitation was more clearly exhibited during this phase. Analysis yielded significant effects of groups ($F = 5.92$, $df = 1/12$, $p < .05$), blocks of trials, and their interaction ($F = 5.16$, $df = 5/60$, $p < .01$). The latter effect again reflects the extinction trend shown by the nonpunished group ($F = 22.83$, $df = 1/60$, $p < .001$) but lacking in Group RE-PE.

Within-Ss effects. Prepunishment speed also reflected within-Ss vicious circle effects. Every gerbil in the RE-PE group ran faster with the addition of punishment ($t = 5.25$, $p < .01$), whereas all PE-RE Ss slowed when punishment was deleted during Phase 2 ($t = 2.77$, $p < .05$). These tests are based on change scores derived from mean prepunishment speeds on Block 4, Phase 1, and Block 6, Phase 2.

Asymptotic self-punitive running. Again, punishment-induced facilitation was greater following a regular extinction phase than directly after avoidance training. An analysis of variance comparing Group PE-RE prepunishment speeds across Blocks 1-4 of Phase 1 with those of Group RE-PE across Blocks 2-5 of Phase 2 revealed only a significant effect of groups ($F = 5.65$, $df = 1/2$, $p < .05$).

Learning self-punitive running. Analyses identical to those of alley speed, i.e., over five two-trial blocks, were done for prepunishment speed. The Groups by Blocks interaction was significant ($F = 4.87$, $df = 4/48$, $p < .01$), as was the effect of groups. This interaction was due to the fact that, again, only Group RE-PE showed a significant increase in speed over blocks of trials.

DISCUSSION

Punishment during the course of gerbils' avoidance responses maintained and increased alley speed

as well as speed prior to the punishment region. These effects were found within Ss, as well as between groups. Furthermore, an extinction trend was reversed through the application of punishment. An initial increase in speed over punished trials during Phase 2, perhaps representing a learning curve, was also found (cf. Beecroft & Bouska, 1967; Melvin & Martin, 1966; Melvin & Smith, 1967).

These results considerably extend the findings of Martin et al (1971), who first reported the vicious circle effect in gerbils. In fact, the functional relationships reported here are quite comparable to those found with rats (e.g., Melvin & Smith, 1967). A comparison of our Fig. 1 with that of Melvin and Smith reveals substantial agreement between curves representing the behavior of these two species. Such compatibility between gerbil and rat data has not always been the case. Campbell, Straney, & Neuringer (1969) found that, unlike rats, gerbils did not show stable response rates on variable-interval reinforcement schedules. They attributed this effect to the gerbils' strong tendency to explore. Similarly, Reynierse, Scavio, & Spanier (1970) reported that, compared to rats, gerbils showed very slow food-reinforcement performance in a runway, and speculated that this effect was due to the gerbils' extreme curiosity.

In a pilot study, we had observed considerable exploratory behavior during extinction phases. Such behavior competed with the running response, so that gerbils met the extinction criterion quickly, e.g., in 20-30 trials. To counteract this tendency, time available to explore the apparatus was lengthened from 10 to 20 min and shock intensity increased. These changes enabled us to use the "shift" design; however, the slopes of the regular extinction curves still appear steeper than those found with rats (cf. Melvin & Smith, 1967).

Asymptotic speeds during the punishment condition were greater when the punishment phase followed regular extinction than when punishment followed avoidance training immediately. This effect is suggested by the data of Melvin & Smith (1967); however, it was not statistically significant in their study. Since shock punishment had a stronger effect following a period without shock, rather than avoidance training, in which shocks occur more frequently, this phenomenon may be related to some type of contrast or

adaptation-level effect.

Delude (1969) concluded that the vicious circle phenomenon was a result of "measurement artifact," basing his argument on failure to find statistically reliable differences between punished and nonpunished rats on *preshock* response measures. However, under more optimal conditions, including a longer prepunishment zone, Siegel, Melvin, & Wagner (1971) found facilitative effects of punishment in the *preshock* region. Both studies involved escape training and rats as Ss. Our analyses of prepunishment speed substantially extend these latter findings, in that they reflected punishment-induced facilitation (1) after avoidance training, (2) within Ss, and (3) with gerbils. This measure also indicated an apparent learning effect during initial self-punitive running (Phase 2).

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