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SUPPLEMENTARY REPORTS

PUNISHMENT AND CHOICE IN THE RAT[1]

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Rats were trained on the basis of larger or more immediate reward to 100% choice of 1 side of T mazes which minimized external cues as bases for choice. After shock was introduced on this higher positive incentive side, number of trials taken to reverse to 100% choice of the nonshock, lower positive incentive side proved to be a positive function of the discrepancy in positive incentives between the 2 alternatives. This finding held both when punishment was associated with highly distinctive proprioceptive feedback cues, and when such cues were considerably less distinctive. The effects of punishment were largely specific to the punished response. The results were interpreted in terms of a "negative incentive" conceptualization of punishment.

Logan's formulation (1960) of the effects of punishment assumes that it produces negative incentive. Two hypotheses follow from this assumption. First, punishment should reduce the tendency to perform the punished response and, insofar as the proprioceptive feedback cues are distinctive, the reduction in performance should be specific to that response. Second, the choice between two responses differing in both positive and negative incentive should be systematically related to both the size of the difference in reinforcement and the size of the difference in punishment. The purpose of the present study was to determine whether such outcomes could be obtained, under conditions of maximal distinctiveness of proprioceptive feedback cues (Experiment 1), and under conditions of considerably lessened cue distinctiveness (Experiment 2). Distinctive external cues were minimized in both experiments. The size of the difference in positive incentives was varied.

METHOD

Subjects

Forty-two 90-day-old male albino Sprague-Dawley rats were used. They were housed in individual living cages in the same room as the apparatus, and were maintained on 12 gm. of Purina laboratory chow per day.

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Apparatus

Two T mazes with identical floor plans were used in Experiment 1. Each had a start box 9 in. long, a choice area 3 in. square, and two wings 12 in. long, set at right angles to the start box. The choice area was separated from the start box and wings by guillotine doors. Each wing ended in a wingback 3 in. square, the floor of which was a shock grid. The direction of the wingbacks was such that each maze's plan resembled an E. Thus, when touching the grid, *S* was in a turning position similar to that used at the choice point. The width of the mazes was 3 in., and the height 4 in.; the mazes had hinged ceilings of wire mesh, and were painted gray except for the wings and wingbacks. In one maze, the left wing and wingback were white, and the right wing and wingback black. The colors were reversed in the other maze.

The bars of the grid were connected in a parallel circuit with condensers and a transformer to permit shock of 100 msec. duration to be delivered through 5 K ohms series resistance when *S* depressed the grid with enough force to spring a sensitive microswitch. Food cups ½ in. above the grid, at the end of each goal box, were pushed in position manually upon the springing of the microswitch. A Springfield standard timer timed running speed between the raising of the start-box door and the springing of the microswitch. This microswitch also activated a second Springfield standard timer, to time delay of reward. Each maze when in use was lighted by a single bare 25-w. bulb hanging 15 in. above the choice area.

The apparatus for Experiment 2 was identical, except that the wingbacks were replaced by goal boxes of the same size and characteristics, which were added as extensions to the wings. The floor plan of each maze then resembled a T.

Procedure

Trials were administered in blocks of four, with two blocks given each day. The first trial of each block was free, and the next three were forced in either AABB or ABBA order, where A stands for the side chosen on the free trial. The order of forcing and the maze used were counterbalanced, minimizing any systematic effect of color, order, or maze. On all trials, a guillotine door was closed after *S* left the start box, and another after it left the choice area, to prevent retracing.

Experimental Design

Experiment 1. Five groups of *S*s were tested. The "no-discrepancy" group ($N = 8$) was given 28 training blocks with five pellets of immediate food reward offered in each goal box, and no shock applied. They were then given 38 test blocks under the same reward conditions, but with shock applied on the side preferred in training. At the end of these trials, all *S*s had reached a criterion of eight successive choices of the nonshock side, and 54 further test blocks were given with the shock side reversed.

The remaining four groups of *S*s ($N = 4$ in each) received, first, 16 blocks of training trials with four pellets of immediate food reward in each goal box, and no shock. Differential positive incentives (magnitude or delay of reward) were then introduced for the two responses, with the greater positive incentive given on the side not preferred in initial training. For the two "low-discrepancy" groups the values were 2 vs. 4 pellets of immediate food reward (magnitude) and 0 vs. 6-sec. delay of 4 pellets of food reward (delay). For the two "high-discrepancy" groups the values were 2 vs. 6 pellets of immediate food reward (magnitude) and 0 vs. 14-sec. delay of 4 pellets food reward (delay). Finally, each group began receiving shock on the higher positive incentive side when all *S*s in the group reached a criterion of eight successive choices of that side. Both high-discrepancy groups reached this criterion in 24 blocks of trials, while the two low-discrepancy groups did so in 38 and 48 blocks, respectively. The differential positive incentive conditions continued throughout the shock trials. Each *S* in Experiment 1 received a total of 120 blocks of trials.

In all groups, shock was introduced at 100 v. and increased gradually to 550 v.[3] Choice on the free trial, and running speed on the final forced trial to each side in each block, were measured.

Experiment 2. The *S*s were randomly separated into two groups ($N = 8$ in each) which received treatment identical to that given the "low discrepancy-magnitude" and "high discrepancy-magnitude" groups in Experiment 1 with two exceptions: the initial equal-reward training trials were omitted, and shock was introduced on the high-reward side only after all 16 *S*s had attained a criterion of eight successive choices of the high-reward side. All *S*s thus received 36 blocks of trials with differential reward and no shock, and 112 blocks of trials with both differential reward and differential shock.

Results

Prior to the introduction of shock, all *S*s in the high- and low-discrepancy group achieved 100% choice of the high positive incentive side. All *S*s in the no-discrepancy group attained 100% choice of the nonshock side after the introduction of shock. Hence the present apparatus and procedure appear to have been adequate to detect either differential positive incentive alone or differential negative incentive alone.

In both experiments, running speed to the shock side declined rapidly after the introduction of shock, while running speed to the nonshock side declined very slowly ($p < .001$ for the Blocks $\times$ Side interaction in each experiment). Using the last eight preshock blocks for purposes of comparison, there was no significant decline in speed to the nonshock side in Experiment 1 at any point in the shock blocks. In Experiment 2, the decline was not significant at any point in the first 40 shock blocks, but it was highly significant for the final eight (one hundred and fifth to one hundred and twelfth) shock blocks ($p < .001$). It appears, therefore, that the decline in running speed after the introduction of

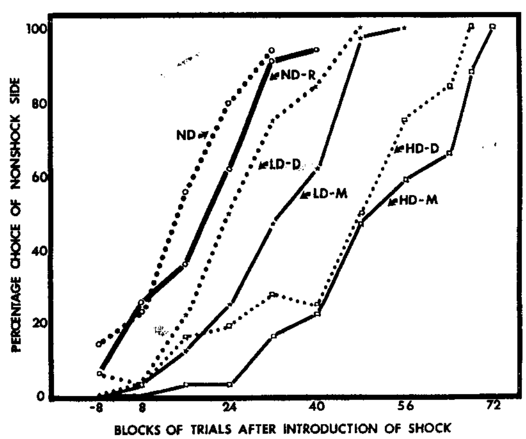

FIG. 1. Percentage choice of nonshock side after introduction of shock (Experiment 1). (In this figure, ND and ND-R refer to the no-discrepancy condition before and after reversal; LD-D and LD-M refer to the low discrepancy, delay, and low discrepancy, magnitude conditions; and HD-D and HD-M to the high discrepancy, delay, and high discrepancy, magnitude conditions.)

[3] Half the *S*s in each group were given 100-v. shock for 16 blocks, then 200-v. shock for 16 blocks, etc. Increments in shock were more finely graduated for the remainder of *S*s, but proceeded at the same pace. This difference in procedure had no apparent systematic effect on choice or on running speed.

shock was relatively specific to the punished response. A decrement in performance of the nonpunished response was noted only at high levels of shock in Experiment 2. This finding contrasts with Estes' (1944) finding that the effects of punishment generalize to nonpunished responses. Presumably the critical difference between Estes' two-bar situation and the present E and T mazes involves the distinctiveness of response cues.

Second, the speed with which choice was reversed after the introduction of shock was inversely related to the magnitude of discrepancy in positive incentives. Using a criterion of seven choices of the nonshock side out of eight free trials, the no-discrepancy group in Experiment 1 reversed more quickly than did the low-discrepancy *Ss* ($U = 2.52$, $p < .02$), which in turn reversed more quickly than did the high-discrepancy *Ss* ($U = 2.10$, $p < .05$). These data are shown in Figure 1. In Experiment 2 the data were quite similar; the low-discrepancy *Ss* again reversed more quickly after the introduction of shock than did the high-discrepancy *Ss* ($U = 2.20$, $p < .05$). These results complement Bower and Miller's (1960) finding that performance in an approach-avoidance conflict declines after the introduction of shock as an inverse function of the amount of reward offered for the response.

Finally, it should be noted that although the present data suggest the possible fruitfulness of a negative incentive theory of punishment, they do not go far toward actually constructing it. The various parameters of both reward and punishment will have to be specified quantitatively before unique predictions could be made about any particular situation.

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SUPPRESSION OF EXPLORATORY BEHAVIOR BY AVERSIVE STIMULATION[1]

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To determine the effects of shock-induced fear on exploratory behavior, 144 mice were observed in an open field. Conditions compared were 0, 2, 4, or 8 shocks in the test situation, a familiar vs. a novel test situation, and shock vs. no shock administered prior to the exploratory test. The test shock suppressed behavior as a negatively accelerated function of the number of shocks and suppression tended to be relatively greater in the familiar than in the novel environment. Preshock did not influence the suppressive effects of test shock, although preshock did have the general consequence of reducing levels of exploratory behavior.

Although conditioned fear is frequently viewed as energizing activity, thus permitting escape from fear-eliciting cues, under some circumstances fear has an opposite effect, that of suppressing ongoing activity. This latter consequence of fear was observed by Montgomery and Monkman (1955) who found that exposing rats to aversive stimulation during the exploration of a novel maze resulted in the suppression of exploratory behavior. The purpose of the present study was to examine further such suppression as a function of three variables: the frequency of aversive stimulus presentation, the

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