Journal of Comparative and Physiological Psychology
Vol. 53, No. 1, 1960

EFFECTS OF AMOUNT OF REWARD ON STRENGTH OF APPROACH IN AN APPROACH-AVOIDANCE CONFLICT[1]

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In a recent discussion of approach-avoidance conflict theory, Miller (1959) assumed that the strength or excitatory potential of the approach response should vary with factors which have been found to affect performance in non-conflict situations, namely: (1) the number of reinforced trials, (2) the strength of drive motivating the approach response, (3) the delay of reward, and (4) the amount of reward. He has also emphasized the importance of using several different test situations and measures to confirm assumptions about intervening variables, such as excitatory potential for the approach response.

With an increase in the excitatory potential for the approach response, stronger punishments (electric shocks) should be required to prevent *S*s from reaching the goal. This deduction has been confirmed for Variables 1 through 3 listed above (Miller, 1944, 1959). The purpose of the present experiments was to test the effect on approach-avoidance conflict of Variable 4, the amount of reward.

It is known that increases in amount of reward increase excitatory potential as measured either by the speed of running down a straight alley to reward (Crespi, 1942; Beier, 1958) or by the choice of that response receiving the larger of two rewards (Davenport, 1959). It is predicted that increasing the amount of reward will produce corresponding increases in the strength of electric shock required to deter *S* from the goal. Confirmation of this deduction with the new measure, resistance to conflict motivated by punishment, would increase not only the generality of the law but also the usefulness of the concept of excitatory potential for the approach response.

In a small pilot study[3] conducted to test this hypothesis, six rats were trained to run down a straight alley and push open a panel to get food. Two of the rats received nine food pellets (.04 gm. each), two received three pellets, and two received one pellet. After 90 training trials a weak, 60-msec. shock was introduced at the goal, and its intensity was increased gradually and stepwise over blocks of 10 trials. During the shock series the speed curves of the three groups declined at differing rates, the relative rate of decline being inversely related to the amount of food given; the curves of declining speed diverged so that the differences between the groups were progressively magnified as the shock increased.

The results of this first pilot study led us to do a second pilot study varying reward magnitude over a larger range (1, 5, 10, 10-partial, 15, and 25 pellets). However, the shock series was changed so that after starting at a weak intensity, the shock at the goal was increased 15% on each trial. In contrast with the first study, only a small divergence of the curves was observed during the punishment series; that is, the relative rates of decline of the speed curves were about the same for all reward groups.

To clarify the differences between these studies, a third experiment was conducted and is reported in detail here. The experiment was a factorial design with large or small reward as one factor, and slowly or rapidly increasing shock series as the other factor. Our expectation was that the slowly increasing shock series would magnify the differences between the large- and small-reward groups, whereas the rapidly increasing shock series would not magnify the differences.

METHOD

Subjects

The *S*s were 20 male albino rats, 90 days old, of the Sprague-Dawley strain. They were housed in

[1] This research was carried out with funds from a grant to Neal E. Miller, M647, from the National Institute of Mental Health of the National Institutes of Health, Public Health Service, Department of Health, Education and Welfare, Bethesda, Maryland. The experiments were carried out during Gordon H. Bower's tenure on a predoctoral Fellowship, MF-8585, from the National Institutes of Mental Health.

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[3] The two pilot studies were carried out with the assistance of Jane Levin; Russell Tousley assisted in the main experiment reported here.

individual living cages with free access to water. For 7 days before pretraining they were placed on a feeding schedule of 13 gm. of Purina lab chow per day and were handled daily.

Apparatus

The runway was 60 in. long, 4 in. high, and 4 in. wide, with a wire-mesh top and bottom. The first 7 in. comprised the startbox and the last 12 in. comprised the goalbox; both compartments were separated from the alley by guillotine doors. The goalbox had a grid floor of $\frac{1}{16}$-in.-diameter bars spaced $\frac{1}{2}$ in. apart, and a swinging Plexiglas door hanging 2 in. in front of a tray which concealed the food. When this door was pushed forward $\frac{3}{4}$ in., a magnet secured to the back wall of the goalbox attracted an iron weight on the back of the door, snapping open the door permanently, actuating a microswitch, and allowing access to the food tray.

Running time from the opening of the startdoor to the operation of the goalbox microswitch was measured to .01 sec. by an electric timer. The goalbox grids were connected in series with the output of a transformer through a voltage divider which permitted variation in the applied voltage. In addition, a .25-meg. resistor was placed in series with *S*. Shock was applied for 60 msec.

Procedure

The *S*s were first trained to push open the food panel and eat one food pellet placed in the tray. After they met a criterion of pushing back the panel and eating within 5 sec. on three consecutive placements in the goalbox, they were randomly assigned to two groups of 10 *S*s. One group received 10 P. J. Noyes food pellets (.04 gm. each) on every trial; the other group received *one pellet on each trial.*

The *S*s were first trained to run with no shock at the goal. Four trials a day were given for 10 days, followed by 2 trials a day for 10 days. Subjects were run in rotation through each trial. After 60 training trials a 75-v. shock was introduced at the goal, given for 60 msec. when *S* pushed open the panel in front of the foodcup. Two shock trials a day were run for 45 days. For half the *S*s (fast shock increase) the shock was increased 25 v. each day; for the other *S*s (slow shock increase) the shock was increased 50 v. every fifth day. An *S* was given a speed score of zero if it failed to open the fooddoor within 60 sec. Subjects that stopped running continued to receive their trials along with the other *S*s. The *S*s in the fast shock condition were dropped from the experiment after 30 shock days since none of these *S*s had responded for six days previous to this.

The ration of 13 gm. minus the amount of food received in the alley was given to *S* about 10 min. after its last trial of the day.

Results

Acquisition

Learning curves are shown in the left half of Figure 1. The speed curves gradually diverge over training, with the curve for the large-

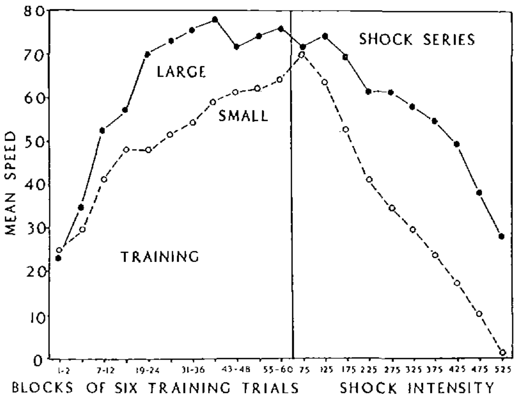

Fig. 1. Performance on training and shock trials for large- and small-reward groups.

reward group reaching a higher asymptote than the curve for the small-reward group. However, it is not clear that the small-reward group has attained its asymptote by the end of training. On the last five training trials (55–60) the difference in speed is reliable at the .05 level (t = 2.10, df = 18). This result confirms those of previous studies (Crespi, 1942; Beier, 1958).

Test with Electric Shock

Since statistical analysis showed that the strength of electric shock was the crucial variable and that there was no suggestion of a difference between the two groups for which the shock increased at different rates, these groups were combined according to strength of shock received instead of according to number of trials. The results are shown in the right half of Figure 1, in which the scale on the abscissa is shock intensity instead of trials. The speed of the slow-increase group at a given shock intensity was plotted by averaging together the speed scores during the five days after the specified shock intensity began. Subjects in the rapidly increasing shock condition had only one day (two trials) at each intensity. To obtain a more stable estimate of their performance, speed scores for the preceding and following days were used in the average, so that the point plotted for say, 175 v. is the average speed on days following shocks of 150, 175, and 200 v. at the goal.

These average speeds at the different shock intensities were analyzed according to a groups-by-repeated-measurements design (Edwards, 1950). This analysis shows that speed decreases with stronger shock ($p < .001$) and that the over-all speed of the large-reward group is greater than that for the small-reward group ($p < .001$). Furthermore, the interaction of amount of reward with strength of shock was highly reliable ($p < .001$), indicating that the curves for the large- and small-reward groups diverge significantly as the shock was increased. This significant divergence was not due solely to earlier failures to respond in the small-reward group since the speed curves diverged significantly even before response failures occurred.

The variable of increasing the shock rapidly or slowly produced no reliable effect on speed at a given shock intensity. In other words, in the ranges used in this experiment the strength of shock was much more important than the rapidity with which *S* had been brought up to this shock level.

Finally, when the intensity of shock at which each rat failed to run was calculated, it was found that *S*s in the small-reward group were stopped by a weaker shock intensity than were *S*s in the large-reward group ($p < .01$).

Discussion

The results, both in terms of speed scores and criterion for complete stopping, confirm the deduction that larger rewards produce an approach response that is stronger when measured by resistance to conflict produced by electric shock at the goal. This result increases the generality of the principle that the excitatory potential of a response increases with the amount of reward. It also gives additional meaningfulness to the concept of excitatory potential, since an intervening variable is useful only when the results of a number of different manipulations and measurements agree (Miller, 1959).

Another finding in both this and the pilot study was that the speed of the small-reward group declined more rapidly with punishment than that of the large-reward group. Thus, with increasing punishment, the two curves appear to diverge. It might be argued that this divergence is an artifact of unequal units of speed which are compressed at the top of the scale and expanded in the middle range. However, one cannot explain a divergence of both the learning curves as they increase and the punishment curves as they decrease on the basis of the same distortion in scale units. Either one or both of these divergences must be genuine.

Hull (1951) has shown that the divergence of the learning curves of groups given different amounts of reward would result from the assumption that habit and incentive combine multiplicatively. To account for the divergence observed here during punishment, an additional assumption would be required (e.g., that competing responses or inhibitory factors due to punishment are learned at a slower rate when the approach and goal responses are vigorous).

Can any single assumption account for both types of divergence? One hypothesis (Miller, 1959, p. 246) that appears to do so is that the primary effect of motivation and reward is to enable approach responses to overcome opposing factors, such as competing responses or the effort involved in making fast responses. According to this hypothesis, relatively effortless responses (e.g., thoughts) that are not opposed by strong competing responses could be learned and maintained with minimal reward. The differential effect of amount of reward is expected to be small when the factors opposing performance are negligible, and will increase as the opposing factors are increased. There is, of course, a limit to this increasing reward differential; when the factors opposing performance are extremely strong, the approach response will not occur and the reward differential will be zero. In short, the effect of a difference in reward is expected to be an increasing, then decreasing, function of the strength of factors opposing performance.

Consider the hypothetical case where neither increased effort nor punishment opposes fast running. Then we would expect *S*s in the large- and small-reward groups to run at the same maximum speed, since running fast is selectively reinforced in that it gets the reward sooner and there are no opposing factors to limit speed. In fact, however, under the conditions of the first half of our experiment, faster responses were opposed by the increasingly greater effort involved as speed increased during the later part of learning. In the second half of the experiment, fast responses not only require more effort, but also get the shock sooner; in addition, the shock elicits responses incompatible with approaching the foodcup. Since, according to this tentative hypothesis, the effect of differences in amount of reward is a function of the strength of factors opposing the response, the conditions of our experiment imply diverging curves during acquisition and diverging, then converging, curves during the series of increasingly stronger shocks.

It is interesting to note that the decrement produced by shock in this experiment is different from that produced by extinction in an experiment by Beier (1958). In her study, rats given runway training with the larger reward extinguished faster than those trained with the smaller reward; the speed curves converged and actually crossed. This result, diametrically opposed to ours, indicates a difference between performance decrements produced by extinction and by punishment. A similar contrast of extinction and punishment is provided by the fact that while Miles and Miller (1936) found that alcohol increases the decrement due to extinction trials, Conger (1951) found that alcohol relieves a conflict induced by punishment.

Finally, while there was no difference between the fast and slow increments in shock used here, other results from our laboratory show that over a larger range this variable can have a reliable effect. In an unpublished experiment Faust found that rats in an approach-avoidance conflict could be trained to continue running to a strong goal shock if they had been gradually adapted to weak, then progressively stronger, shocks. By contrast, if the strong goal shock was suddenly introduced with no adaptation, the rats stopped running after two or three shocks. The present *E*s did not vary the rate of shock increase through as large a range as did Faust.

Summary

The effect of amount of reward on strength of approach in an approach-avoidance conflict was studied. Rats were trained to run down a straight alley to food reward; some *S*s received a large amount of reward, others received a small amount. After training, a brief, mild shock was introduced at the goal and increased in intensity over subsequent trials. For half the *S*s the shock intensity was increased 25 v. every second trial; for the other *S*s, the shock was increased 50 v. every tenth trial.

The acquisition results replicate the common finding that asymptotic speed is faster with larger reward. During the subsequent punishment series, speeds declined rapidly in the small-reward group and more slowly in the large-reward group. The net result was a magnification of the group differences obtained at the end of training. As this result suggests, a stronger shock was required to deter the larger-reward *S*s from the goal. The variable of increasing the shock relatively rapidly or slowly produced no reliable effects on speed at a given shock level.

The results support Miller's theory of approach-avoidance conflict. They also increase the generality of the concept of excitatory potential for the approach response in that variables assumed to affect excitatory potential have corresponding effects on speed and choice measures and the new measure, resistance to conflict, used in this study.

REFERENCES

Beier, E. Effects of trial-to-trial variation in magnitude of reward upon an instrumental running response. Unpublished doctoral disertation, 1958, Yale Univer.

Conger, J. J. The effects of alcohol on conflict behavior in the albino rat. *Quart. J. Stud. Alcohol*, **12**, 1951, 1–29.

Crespi, L. P. Quantitative variation of incentive and performance in the white rat. *Amer. J. Psychol.*, 1942, **55**, 467–517.

Davenport, J. W. Analysis of a simple selective learning situation involving differential magnitude of reinforcement. *J. comp. physiol. Psychol.*, 1959, **52**, 349–352.

Edwards, A. L. *Experimental design in psychological research*. New York: Rinehart, 1950.

Hull, C. L. *Essentials of behavior*. New Haven: Yale Univer. Press, 1951.

Miles, W. R., & Miller, N. E. Alcohol and removal of reward. An analytical study of rodent maze behavior. *J. comp. Psychol.*, 1936, **21**, 179–204.

Miller, N. E. Experimental studies of conflict. In J. McV. Hunt (Ed.), *Personality and the behavior disorders*, New York: Ronald Press, 1944. Pp. 431–465.

Miller, N. E. Liberalization of basic S-R concepts: Extensions to conflict behavior and social learning In Sigmund Koch (Ed.), *Psychology: A study of a science*. Vol. 2. New York: McGraw-Hill, 1959.

(Received May 14, 1959)