

Effects of relative reinforcer duration on concurrent response rates*

S. F. WALKER and H. M. B. HURWITZ
University of Tennessee, Knoxville, Tenn. 37916

For three rats, responses on two bars were reinforced equally often, but with different reinforcer durations, on a variable interval schedule. With only one reinforcer being changed at a time, five pairs of reinforcer durations were tested in exposures of between 9 and 30 sessions. When a reinforcer duration was changed, the rates of both responses usually altered gradually, suggesting that the absolute rate of a response was controlled by the relative duration of its reinforcer. The relative rate of a response (the rate of one response divided by the sum of both response rates) was a linear function of the relative duration of its reinforcer, for the three values tested.

In the present experiment, rats were rewarded with equal frequency for two similar responses. One response, Ra, produced reinforcers of 3 sec duration, and the other response, Rb, produced reinforcers of only 1 sec duration. Common sense and data reported by Catania (1963) would suggest that the strength of Ra in this case would be at least twice that of Rb. A simple interpretation of such a result is that the strength of a reinforced response is an increasing function of the absolute properties of its reinforcer. But this interpretation also implies that the strength of Rb would remain unchanged, while the strength of Ra would be reduced if Rb continued to produce 1-sec reinforcers, but the reinforcer for Ra was changed from 3.0 sec to 0.3 sec. Data reported by Rachlin & Baum (1969) and Walker, Hurwitz, & Schnelle (1970) suggest, to the contrary, that the absolute strength of Rb would increase in this instance. The finding in those two studies was that the absolute rate of a reinforced response was inversely proportional to the duration of reinforcers concurrently delivered for an alternative response. The simple interpretation mentioned above is, therefore, not always correct. A more general assumption might be that the absolute rate of a response is a function of the relative duration of its reinforcers. Relative duration of reinforcer is defined as the absolute duration of one reinforcer divided by the sum of all reinforcer durations delivered for concurrent responses. This assumption integrates two possible findings: first, that the rate of one of two responses, Rb, changes as a function of variations in the duration of the reinforcer produced by the alternative response, Ra, (e.g., Rachlin &

Baum, 1969); second, that the relative rate of each response matches roughly the relative duration of its own reinforcer.

The latter result has not yet been reported. In Rachlin and Baum's procedure the rate of one response was kept low and constant by the signaling of reinforcement availability, and Walker et al (1970) found inconsistent changes in the rate of the response reinforced with varied reinforcer durations. However, Catania (1963) reported that absolute rate of response on each of two pigeon keys was roughly proportional to the absolute duration of the reinforcer produced. This implies that matching of relative rate to relative reinforcer duration occurred. But in the procedure used (Catania, 1963) every time one reinforcer duration was changed the other duration was changed by the same amount, in the opposite direction. Thus, it is not clear whether the rates of response were affected by the absolute or by the relative values of reinforcer duration. The present experiment was designed to investigate whether or not matching of relative response rate to relative reinforcer duration could occur, and how far the absolute rates of both responses were influenced, when only one reinforcer was changed at a time, in a two-bar concurrent schedule.

SUBJECTS

Three male Long-Evans rats were maintained on a 22-h deprivation regimen at 80% of their free-feeding body weights. They were about 9 months old at the start of the experiment and had previously been trained to respond on both bars in the experimental chamber by concurrent reinforcement of both responses on a single 1-min VI schedule with 3-sec reinforcers. Water was always available in the home cage.

APPARATUS

A two-bar chamber, manufactured by Campden Instruments, Ltd. was used. There was one reinforcement magazine,

which was situated in the center of one wall of the chamber with identical bars mounted on either side. The bars were 38 mm wide and 2 mm thick, and projected 19 mm into the chamber, 38 mm above the floor, with a space of 13 mm between the nearest points of each bar and the door to the magazine. A force of .15 N was required to depress the bars, and a downward displacement of 5 mm operated a reed switch via the movement of a magnet. The reinforcement magazine was behind a Plexiglas door, 50 mm high and 38 mm wide, suspended from horizontal hinges at the top. The bottom of the door and the metal platform which extended behind it were at the same level as the floor of the chamber. A hole, 13 mm in diam, was drilled in the platform behind each door. A 16% sucrose solution could be pumped from a reservoir in a horizontal jet 7 mm below the hole, and the rats could lick at the solution only by inserting their tongues through the hole while the pump was on. Excess solution ran back into the reservoir, and thus the duration of access to the sucrose solution could be limited to the period for which the pump was on, which is the period defined as duration of the reinforcer. At reinforcement, a barpress turned on the light in the reinforcement magazine, and the next opening of the magazine door turned on the sucrose pump for a fixed period of time which defined reinforcer duration. When a left barpress was reinforced, the light was on continuously from the occurrence of the barpress until the pump stopped, but when a right barpress was reinforced the light flashed on and off at 10 Hz for the equivalent interval.

PROCEDURE

Throughout the experiment daily sessions were 60 min, and responses on both bars were reinforced concurrently on a single 1- VI schedule. A method of scheduling reinforcers was adopted which assured that the obtained frequencies of reinforcement for the two bars would be equal. After a reinforcement, the bar to be reinforced next was determined by an irregular sequence wired on a 22-position stepping switch. The repeating sequence of reinforcements for left (L) and right (R) barpresses was: . . . LLLRRRLRRRLRLRLRLR . . . The stage in the sequence at the start of each session was undetermined. To prevent reinforcements from occurring immediately after a switch from one manipulandum to another, a reinforcement set up by the VI tape was delivered only by a press on the appropriate bar, which occurred at least 3 sec after the release of the other bar and the release of the magazine door. When a reinforcement was

*Research supported by Grant MH 12115-03 to Dr. H. M. B. Hurwitz. Reprints may be obtained from S. F. Walker, Department of Psychology, University of Tennessee, Knoxville, Tennessee 37916.

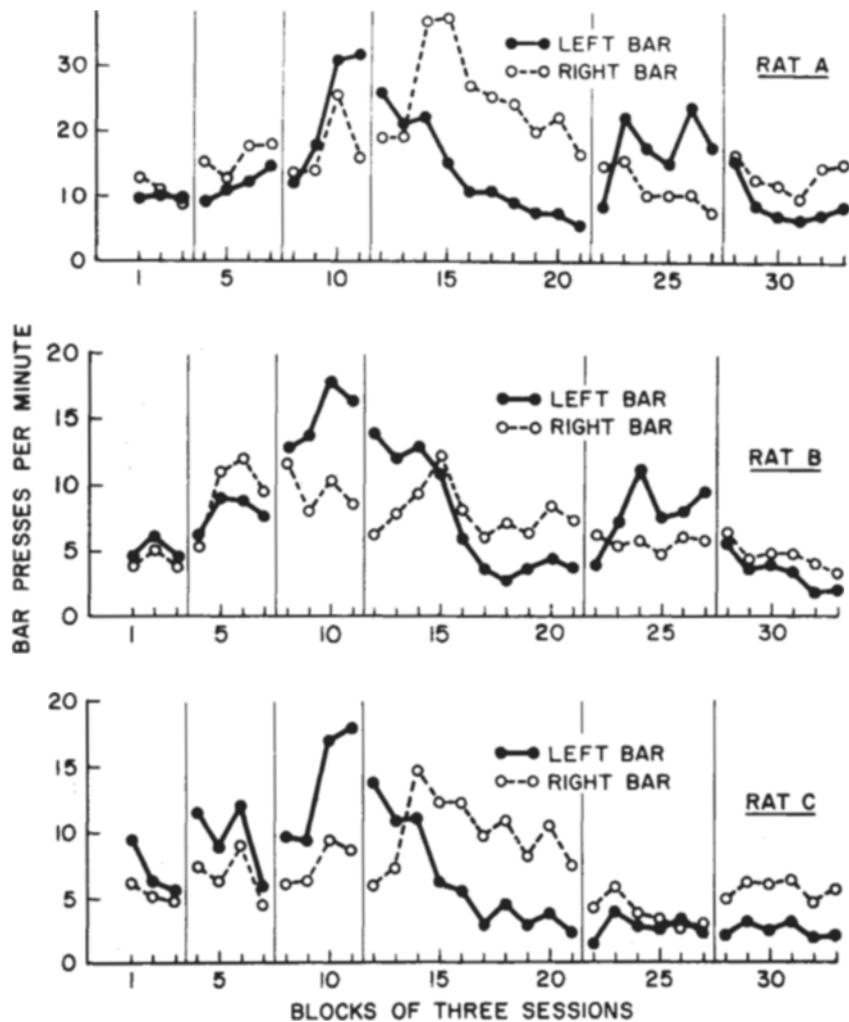


Fig. 1. Rates of response on each bar for the individual rats throughout the experiment. The points plotted are means of consecutive three-session blocks. The durations of the reinforcers for the left (L) and right (R) barpresses are given in seconds at the top of the figure for each experimental condition.

set up by the VI tape, the tape stopped until the reinforcement was completed, at which point the tape started again and the stepping switch moved to the next position.

The order of experimental conditions is given in Fig. 1. For the first nine sessions the duration of reinforcers for both bars was 3.0 sec. During the next nine sessions both reinforcers were 2.0 sec, and for the remainder of the experiment the durations of reinforcers produced by presses at the left and right bars were dissimilar. The pairs of reinforcer durations used, given in seconds with the left bar reinforcer first, were as follows: 3.0:1.0, 0.3:1.0, 0.3:0.1, and 0.3:1.0. The number of sessions run in each of these four conditions was 12, 30, 18, and 18.

RESULTS AND DISCUSSION

The observed number of reinforcements per session was about 25 for each bar,

throughout the experiment. The rates of response on the left and right bars are plotted as means of successive blocks of three sessions in Fig. 1. The durations of the reinforcers used for the two bars clearly had some control over the individual rates of response. In general, the response reinforced with the longer of the two reinforcer durations was emitted at the highest rate. The one exception to this was with Rat C when the 0.3:0.1 pair of reinforcer durations failed to establish a difference between the two response rates.

It is important to identify two types of rate changes in Fig. 1. First, when the reinforcer duration for one bar was changed, there was a tendency for rate of response on that bar to change in the same direction. For instance, the change from 3.0 sec to 0.3 sec for the left bar reinforcer after the 11th three-session block was followed by a gradual decline in response

rate on the left bar. Changing the right bar reinforcer from 1.0 sec to 0.1 sec and back to 1.0 sec in the last three experimental conditions produced corresponding changes in rate of response on the right bar for Rat A and Rat C. The second type of rate change occurred when the rate of a response was affected by a change in the duration of reinforcers for the other response. When the duration of the left bar reinforcer was reduced from 3.0 sec to 0.3 sec after the 11th three-session block, rate of response on the right bar increased during the next four three-session blocks, even though the right bar reinforcer remained at 1.0 sec. Similarly, the rate of response on the left bar for Rat A and Rat B varied systematically over the last three experimental conditions, even though the left bar reinforcer was held at 0.3 sec while the right bar reinforcer was varied.

The direction of this second type of rate change is consistent with the assumption that the absolute rate of one of two concurrently reinforced responses is controlled by the relative duration of its reinforcer, as suggested by Rachlin & Baum (1969). But it is uncertain whether the changes in rate of a response should be regarded as permanent. Figure 1 shows that rate of response on the right bar had almost doubled by the 4th three-session block, after the left bar reinforcer had been reduced from 3.0 sec to 1.0 sec. But by the 10th three-session block after this change, rate of barpressing for the right bar had returned to the same level observed in the previous condition, with the 3.0:1.0 pair of reinforcer durations. These changes took place over 30 sessions of exposure to the 0.3:1.0 condition, and the other conditions were not in effect for as long a period. One may conclude that the rate of a response whose conditions of reinforcement remained constant varied inversely with the duration of the reinforcer for the alternative response, at least for some period after the alternative reinforcer was changed.

We have previously suggested (Walker et al, 1970) that a satiation factor contributes to changes in absolute rates of response in concurrent schedules of reinforcement. There were instances in the present experiment where total rate of response appeared to be inversely related to reinforcer duration: for Rat A and Rat B total response rate increased when both reinforcers were initially reduced from 3.0 sec to 2.0 sec and with the shift from the 0.3:1.0 to the 0.3:0.1 condition. However, the protracted time course of the rate changes in Fig. 1 implicates some factor that takes as long as 6 to 10 sessions to develop rather than immediate changes in general satiation.

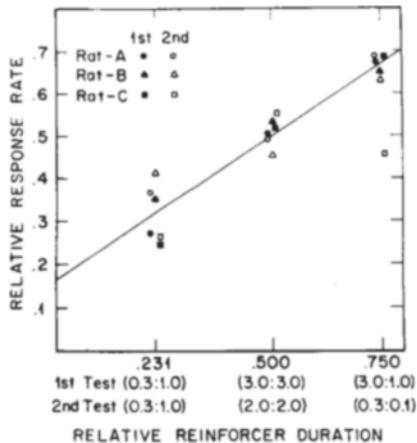


Fig. 2. Relative response rate as a function of relative reinforcer duration for the left bar. The points are means for the last three sessions of the condition indicated. There are separate points for the first and second time a given value of relative reinforcer duration was tested for each rat. The line is a visual fit.

With regard to the effects of changes in reinforcer duration on relative response rate (rate of one response divided by the sum of both response rates), Fig. 2 shows that relative rate of response was a linear

function of relative reinforcer duration for the three values tested. By comparing the points on Fig. 2 with the corresponding absolute response rates in Fig. 1, it is obvious that the degree of matching obtained did not come about because of a consistent relation between the absolute rate of a response and the absolute duration of its reinforcer. Rather, as mentioned above, the rate of a response reinforced by a given reinforcer duration varied considerably as a function of the duration of the alternative reinforcer. Whether the orderly relation between relative response rate and relative reinforcer duration depends on these variations, or vice versa, needs further investigation.

REFERENCES

- CATANIA, A. C. Concurrent performances: A baseline for the study of reinforcement magnitude. *Journal of the Experimental Analysis of Behavior*, 1963, 6, 299-300.
- RACHLIN, H., & BAUM, W. M. Response rate as a function of amount of reinforcement for a signaled concurrent response. *Journal of Experimental Analysis of Behavior*, 1969, 12, 11-16.
- WALKER, S. F., HURWITZ, H. M. B., & SCHNELLE, J. F. Rates of concurrent responses and reinforcer duration. *Psychonomic Science*, 1970, 21, 29-31.

Frustration, competing responses, and error making

JAMES L. BRUNING, Ohio University, Athens, Ohio 45701

RONALD R. SCHMECK, Southern Illinois University, Carbondale, Ill. 62901
and

AVRUM I. SILVER, Ohio University, Athens, Ohio 45701

The effects of competing responses on performance were examined in a simple T-maze where the number of competing responses inherent to the apparatus and situation were minimal, but where their occurrence could be manipulated. Following reversal training, Ss were frustrated just prior to the choice point of the T-maze. The results supported the prediction that frustrative nonreward would increase the general drive level which would, in turn, lead to greater frequency of choice errors.

While the interaction of task variables and emotionally produced drive has been discussed in relation to anxiety, stress, fear, and other hypothesized internal states, the topic has not been dealt with to any extent in the case of frustration. The general finding for frustration, as has been well documented by the animal research of Amsel (1962) and many others, is that running speed in an alley increases following frustrative nonreward. The same finding has been reported for humans, especially children (Ryan & Watson, 1968), when lever movement or pressure exerted serves as the dependent variable. As is apparent, however, all of these studies have employed a simple task of running in a

straight alley or moving a lever where relatively few competing responses are present.

Studies conducted recently by Schmeck & Bruning (1968, 1970), however, have demonstrated that when the task is complex and there is a relatively large number of competing responses present, the results have not shown the typical enhancement of performance.

In these studies, the basic assumptions and hypotheses were derived from the Hull-Spence model, which assumes that an increase in drive (here assumed to be due to frustration) tends to move the normal probability distribution of momentary E values for all response tendencies further

above the L or threshold. In the instances where there are few, if any, competing responses (usually defined as a simple task), the frustration-produced increment in drive would be expected to raise only the correct tendency, thereby enhancing performance. This would be the case in the running-speed data reported by Amsel where animals perform a simple running response, and, in addition, are usually pretrained before the introduction of the nonreward-frustration trials. However, when competing responses are present in large numbers and are close to the strength of the correct response, the increase in drive would raise both the correct and incorrect tendencies into competitive status, thus increasing the probability that one of the competing responses would occur in place of the correct response.

In the following experiment, the effects of competing responses on performance were examined in a simple T-maze where the number of competing responses inherent to the apparatus and situation were minimal, but where their occurrence could be manipulated. Thus, the basic hypothesis was that frustrative nonreward would increase the general drive level of the S, which would, in turn, lead to greater occurrence of a competing response, which was known to be high in the hierarchy.

PROCEDURE

Thirty-nine hooded rats were maintained on a 23-h deprivation schedule throughout the experiment. The apparatus was a T-maze constructed so that there were three goalboxes. The first goalbox was located in the stem of the maze just prior to the choice point, while the second and third goalboxes were placed at the end of each of the arms in the usual fashion. During Phase 1, all Ss ran to the first goalbox which contained two Noyes pellets. After the S had eaten the pellets, the second start door was opened, and the S was required to make a position choice to receive reward in one of the arms of the T. To control for possible position preference, 19 of the Ss were rewarded in the right arm of the maze and 20 were rewarded in the left. Ss were trained in this fashion until they had learned the correct choice to a criterion of 19 of 20. Following the learning to criterion, Ss were divided into three groups of 13 each. During Phase 2, Ss continued to receive 100% reinforcement in the first goalbox, but the arm containing the second reinforcement was reversed. Trials were continued until Ss learned the reversal to a criterion of 5 of 5. Phase 3 represented the critical trials in which the Ss in Groups 1 and 2 were given 10 additional trials under the following conditions. Ss in Group 1 received 50% reinforcement in the first goalbox, while Ss