Response rate and varied reinforcement: Reinforcers of similar strengths¹

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Research has shown that reinforcer variety can increase response rates. To determine whether the reinforcers comprising this variety must differ in reinforcing strength in order to produce this effect, rats were trained to lever press under three reinforcement conditions: pellets-only, sucrose-only, and pellets or sucrose (varied reinforcement). Although the sucrose concentration was made to be roughly equivalent to the pellets in reinforcing strength, the varied-reinforcement still produced the highest response rate.

Several studies have shown that varied reinforcement can produce higher response rates than comparable conditions in which this variety is lacking (e.g., Wunderlich, 1961; Steinman, 1966, 1968). Although it has been demonstrated that this "varied-reinforcement effect" can be obtained whether the comparisons are made between groups or between conditions within Ss, the basis for the effect is still unclear. In all of these experiments, the reinforcers used have not only differed in kind (providing variety in the stimulatory characteristics of the reinforcers); they have also differed in reinforcing strength, i.e., the response rates that each of the reinforcers will produce when delivered separately differ from each other.

Thus, questions remain concerning the relative contribution of stimulatory variety and variety in reinforcement strength in the production of the increased rates found in a varied-reinforcement procedure. The present experiment investigates the effect of varied reinforcement upon response rate when the reinforcers are similar in reinforcing strength.

Subjects

Twelve experimentally naive male hooded rats of the Long-Evans strain served as Ss. When about 100 days of age they were placed on a food deprivation cycle permitting access to Purina Lab Chow for 1 h per day. Water was available ad lib.

Apparatus

Two sound-restricted chambers contained a 13.5 x 7.5 in. Skinner box with a 2 in. wide metal lever on one wall and a 3.5 x 3 in. panel on the opposite wall. Behind the panel was an area for the delivery of 45 mg food pellets and a fountain device for the delivery of sucrose solution. All programming and recording equipment was automatic and inaudible to S.

Procedure

Ss were trained to press the lever, which on a variable interval (VI) schedule having a mean interval of 45 sec (VI 45) resulted in the onset of a 0.5 sec indicator light. Pushing the panel after the onset of the light produced a 45 mg food pellet.

Phase 1. When the above behavioral chain had been established, a tone (T_1) of either 400, 1900, or 4000 cps was presented for six 5 min periods within each session. Completed chains during T_1 were reinforced with food pellets. At the end of a 5 min period the tone ceased and no further responding was reinforced. This time out from reinforcement (TO) continued until S refrained from lever pressing or panel pushing for a minimum of 15 sec, at which time T_1 was reinstated. When for three consecutive sessions the lever pressing rates during T_1 appeared to be asymptotic and no TO lasted more than 20 sec, Phase 1 was concluded.

Phase 2, Part 1. A second tone (T_2) was added in Phase 2. During T_2 , responding was reinforced with a .07 cc drop of 30% sucrose solution. Five minute periods of T_1 were randomly followed by 5 min periods of T_2 within each session. Between each tone was the TO condition. Again, a session consisted of six 5 min periods.

Phase 2, Part 2. Up to this point, the procedures of the present experiment are identical to those used in a previous study (Steinman, 1968). However, in this experiment after Ss had demonstrated a stable difference in lever pressing rates under the two reinforcement conditions of Phase 2, the sucrose solution concentration was decreased in successive sessions until the behavior during T_2 completely overlapped the behavior during T_1 . In other words, using rate as an index of reinforcer strength, the strengths of the two reinforcers were adjusted until they were grossly equivalent. A criterion of at least three consecutive sessions in which the rate during T_2 completely overlapped the rate during T_1 was established, at which time the procedures of Phase 3 were begun.

Phase 3. When lever pressing had stabilized during each of the two tones and responding during TO was again minimal, a third 5 min tone (T_3) was added. During T_3 the reinforcer to be delivered on a particular reinforcement occasion varied randomly between the food pellets and sucrose solution. The 5 min tone periods were also randomly scheduled and each tone period was preceded by a TO. A session was composed of nine tone presentations.

Results

The average lever pressing rate of Ss in Phase 3 is illustrated in Fig. 1. As can be seen, even though the strengths of the two reinforcers were made to be roughly equivalent, the varied-reinforcement condition still produced the highest response rates (F

Fig. 1. Mean lever presses per 5-min in each session of Phase 3.

= 7.82, $p < .01$). A Duncan's test indicated that although the rates in T_1 did not differ reliably from T_2 , they were both different than that of T_3 ($p < .01$).

Ten Ss responded at a higher rate during T_3 throughout Phase 3. However, for three Ss the rate differences between the three conditions were quite small. The other two Ss did not perform at rates during T_3 which could be readily discriminated from those of the other reinforcement conditions.

Discussion

Previous research has emphasized the effect that varied reinforcement can have on increasing the resistance to extinction of a response. For example, Logan (1960) has shown that varied amounts of the same reinforcer will produce greater resistance to extinction than will either the largest amount or smallest amount given consistently. These results are explained in terms of the similarities between varied-reinforcement and partial-reinforcement scheduling.

Similarly, Wunderlich (1961) has found that rats receiving food or water randomly from trial to trial in a runway showed greater resistance to extinction of the running response than Ss receiving food and water or just food or water on every trial. These

results are also interpreted in terms of approximations to partial reinforcement.

However, Logan's data and Wunderlich's data, although similar with respect to extinction performance, are different in the effect of varied reinforcement during conditioning. In Logan's research, Ss receiving randomly varied amounts of the same reinforcer performed at rates between those produced by the largest and smallest amounts. In Wunderlich's study, although the food-only and water-only Ss ran at different speeds, Ss receiving food or water randomly from trial to trial ran at faster speeds than either of these constant-reinforcement groups. The results of the present study and others (Steinman, 1966, 1968) are also in agreement with Wunderlich's.

Taken together, the results of the present experiment and those described above suggest the following conclusions: (1) Varied reinforcement can produce greater resistance to extinction. It appears that the varied reinforcers need only differ in their reinforcing strengths to produce these increases. (2) Varied reinforcement can also result in increased rates of responding. That the varied reinforcers may differ in their reinforcing strengths seems irrelevant to the attainment of this effect. Instead, reinforcement variety, per se, may be central to the production of the increased rates.

References

- EDWARDS, A. L. *Experimental Design in Psychological Research*. New York: Rinehart & Co., 1960.
- LOGAN, F. A. *Incentive*. New Haven: Yale University Press, 1960.
- STEINMAN, W. M. Generalized conditioned reinforcement under a single deprivation condition. *Psychol. Rec.*, 1966, 16, 457-472.
- STEINMAN, W. M. Response Rate and Varied Reinforcement: Reinforcers of Different Strengths. *Psychon. Sci.*, 1968, in press.
- WUNDERLICH, R. A. Strength of a generalized conditioned reinforcer as a function of variability of reward. *J. exp. Psychol.*, 1961, 62, 409-415.

Notes

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