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Conditioned reinforcement via free-operant avoidance scheduling tests*

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Three rats trained on a free-operant avoidance schedule with a 2-sec response-produced auditory stimulus (RPS) for each response were changed to tandem FRX FR1(avoid):s, FRX:s, or a FRX superimposed

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schedule for the RPS. Rates of response and shock density increased under the tandem and FR schedule. Under the superimposed schedules, rate of response increased but shock density remained stable relative to the baseline. Recovery of the avoidance baseline was difficult after the FR avoidance, but reversibility was rapid after the tandem or superimposed schedule. Behavior under the tandem and superimposed avoidance scheduled was characteristic of FR behavior. The increased rates and shock patterns were interpreted as evidence for the conditioned reinforcing properties of the RPS.

Table 1
Summary of Schedules and Number of Sessions Run for Each S

S	Schedule	Sessions
CR-2*	tand FR2 FR1 (Avoid):s	141-159
	tand FR4 FR1 (Avoid):s	160-178
	FR5 Superimposed	179-186
CR-3**	Baseline	1- 26
	FR2 Superimposed	27- 64
	Baseline	65- 73
	FR4 Superimposed	74- 78
	FR3 Superimposed	79- 87
	Baseline	88- 97
	FR3 Superimposed	98-106
	Baseline	107-112
	FR2:s	113-122
	FR3:s	123-129
	Baseline	130-164
	FR3 Superimposed	165-178
	tand FR2 FR1 (Avoid):s	179-184
CR-4†	FR2 Superimposed	83- 87
	FR3 Superimposed	88- 99
	Baseline	100-114
	FR3 Superimposed	115-120
	FR5 Superimposed	121-138
	Baseline	139-150
	tand FR2 FR1 (Avoid):s	151-168
	Baseline	169-174
	FR3 Superimposed	175-181

*Reversibility probes for baseline (Sessions 166 and 177), for FR5 superimposed (Session 174), for tand FR2 FR1 (avoid):s (Sessions 182 and 184).

**Reversibility probes for baseline (Sessions 118 and 172), for FR2:s (Session 182).

†Reversibility probe for baseline (Session 161).

The use of various schedules of reinforcement has provided an effective means of investigating the parameters of conditioned reinforcement in a positive reinforcement situation (Hendry, 1969). Weisman & Litner (1969) demonstrated the reinforcing properties of a Pavlovian conditioned stimulus established independently of the avoidance task used to test its stimulus properties. The purpose of the following research was to study conditioned reinforcement by using aversive control procedures analogous to the superimposed and second-order schedules described in Hendry (1969).

METHOD

Subjects and Apparatus

Three male hooded rats served as Ss. CR-3 was naive at the start, CR-4 and CR-2 had been used in a previous avoidance experiment (Burnstein, 1971). During the experiment, all Ss were maintained on ad lib food and water.

A standard operant conditioning chamber housed in a Lehigh Valley environmental cubicle was used. Contingencies were controlled by electromechanical programming equipment, and data were recorded on digital counters and a Gerbrands cumulative recorder. Grid shock of 2-mA intensity for 0.2-sec duration was delivered by a Grason-Stadler shock generator. A Grason-Stadler white-noise generator produced a 2-sec response-produced stimulus (RPS) which raised the noise level of the chamber from 57 dB to 85 dB.

Procedure

All Ss were stabilized on a free-operant avoidance schedule

R-S = 20 sec (the time between the S's response and the next programmed shock), S-S = 5 sec (the time between programmed shocks when the S does not respond) (Sidman, 1953). Each response reset the R-S timer, and each response with a 2-sec interresponse time produced 2 sec of RPS.

After stabilization, Ss were run on three variations of FR schedules: (1) In the FRX:s schedule, X responses had to be made to avoid the shock; however, each response produced the RPS. In the tand FRX FR1 (avoid):s, the first X responses counted toward the FR requirement, but did not produce the RPS, and the last response avoided the shock (avoid) and produced the RPS(:s). In the FRX superimposed schedule, each response reset the RS timer, but only the X response produced the RPS. The use of X after the FR indicates that the number of responses to meet the FR requirement varied for both Ss and experimental conditions. The term "s" indicates that the RPS and response were correlated. Sessions were 3 h in duration and were run every other day. R-S and S-S intervals remained at 20 and 5 sec, respectively, throughout all schedules. Table 1 shows the schedule order for each S along with the number of sessions for each schedule.

RESULTS AND DISCUSSION

The FRX:s schedule, when X = 2, produced an increase of 4 responses/min and a slight increase in shock density. When X was changed to 3, avoidance behavior broke down so completely that it took 102 h to recover any semblance of the baseline (Fig. 1). Since each response produced the RPS, and since the RPS no longer had any relation to signaling the shock-free condition, any conditioned reinforcing properties the RPS had were eliminated because the information value of the RPS was removed. The tandem schedules also resulted in at least a doubling of the avoidance rate (Figs. 2 and 3) as well as increases in shock density of from 4 to 12 times the baseline densities. Figure 4 shows selected portions of cumulative records for CR-2. The tandem schedules have the more definite cyclic pause-and-burst pattern characteristics of FR schedules. The result of this pattern of responding was that shocks began to occur in clumps. Where previously the S was able to terminate the S-S period rapidly, the tandem schedule resulted in

Fig. 1. Shock and responses per minute for CR-3 as a function of schedule.

Fig. 2. Shock and responses per minute for CR-2 as a function of schedule.

longer periods of S-S. Although efficiency of avoidance responding decreased, the conditioned reinforcing effect of the RPS was demonstrated by the definite FR behavioral pattern.

The reversibility from the tandem schedule to baseline was fairly rapid (Fig. 2, Sessions 166 and 177, and Fig. 3, Sessions 161 and 169-174) compared to that occurring with the FRX:s schedules. The tandem schedule did not disrupt the properties of the RPS.

The conditioned reinforcing properties of the RPS were also demonstrated with the FRX superimposed schedules. Each S increased response rate, with only

Fig. 3. Shock and responses per minute for CR-4 as a function of schedule.

Fig. 4. Selected typical cumulative records for CR-2.

CR-3 showing a slight corresponding decrease in shock density (Figs. 1, 2, and 3). Although the RPS had no behavioral consequences, it was never paired with shock as in the case of the FRX:s schedule, and therefore, apparently retained its conditioned reinforcing properties. In data not shown, CR-3 had a rate increase of 3.5 responses/min when an FR 2 was initially superimposed on the avoidance schedule. In the second and third replications with the superimposed schedule, CR-3 had a rate 1 to 2 responses/min higher than the baseline, without a change in shock density. The typical behavior under a superimposed schedule is shown in Fig. 4. The FR cyclic pattern is not as smooth as the tandem schedule requiring the same number of responses. Returning from the superimposed schedule to baseline required about five sessions for CR-3, although Fig. 1, Session 172, suggests a more rapid reversal.

The results of this study indicate that a stimulus which signals a shock-free period can be used to demonstrate schedule effects on an avoidance baseline. The conditioned reinforcing properties of a stimulus are consistent whether the properties are derived through positive or negative conditioning procedures.

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