Free operant DRL performance maintained by a single electrical brain stimulation reinforcement

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Two rats with chronically implanted electrodes positioned in the lateral hypothalamus were trained to respond on a single lever with only a single ESB reinforcement according to a DRL 30-sec schedule of reinforcement. The results indicated that multielement behavioral chains with multiple ESB reinforcements are not necessary for the comparison of ESB and conventional reinforcers.

Recent investigations (Gibson, Reid, Sokai, & Porter, 1965; Panksepp & Trowill, 1967; Pliskoff, Wright, & Hawkins, 1965; Pliskoff & Hawkins, 1967; Owens & Brown, 1968) have compared schedule behavior maintained by conventional reinforcers (food, sugar water, etc.) with schedule behavior maintained by electrical brain stimulation (ESB). Previous to the present research, ESB was considered as a reinforcer less potent than conventional rewards in terms of maintenance of schedule behavior (Gallistel, 1961).

Pliskoff and his associates (1965, 1967) and Gibson et al (1965) argued that in comparisons of the relative efficiency of ESB and conventional reinforcers, the two reinforcing events must occupy identical positions in a response chain. Typically in the conventional reinforcement situation, the S executes the criterion response and then engages in intervening behavior, such as leaving the bar, approaching the foodcup, etc., prior to the consummatory response. With ESB as a reinforcer, however, the reward is delivered centrally with no necessary intervening behavior. Therefore, the differences attributed to the potency of conventional reinforcers relative to ESB might be due only to the length of the behavioral chain that is reinforced. For example, when conventional reinforcers are withheld, the intervening behavior must be extinguished along with the extinction of the criterion response (barpress). However, when ESB is discontinued, extinction commences with the final chain member which, in this case, is also the criterion response. This could partially account for the faster extinction found with ESB-reinforced animals as compared to conventionally reinforced Ss.

Pliskoff et al (1965) and Pliskoff & Hawkins (1967) have reported that comparable results are obtained when ESB is delivered contingent upon the completion of a behavioral chain analogous to that used with

conventional reinforcers. Specifically, Ss were required to complete an intermittent reinforcement schedule on one lever in order to produce a second lever upon which multiple ESB reinforcements could be earned. By employing a multielement chain with multiple reinforcements, Pliskoff et al (1965) were able to maintain fixed-interval (FI 10 sec to 10 min), fixed-ratio (FR 5 to 100), variable-interval (VI 2 to 4 min), and differential reinforcement of low rates (DRL 10 sec to 3 min) behavior on the first response lever.

Two recent investigations have, however, questioned the need for a multielement chain followed by multiple ESB reinforcement. Brown & Trowill (1970) report "typical" VI and FI schedule performance on a single lever (one-element chain) when five ESB rewarded responses were permitted following the completion of the interval. These results would indicate that a multielement behavioral chain is not a necessary condition for the comparability of ESB and conventional reinforcers. Likewise, Owens & Brown (1968) have questioned the necessity of delivering multiple ESB reinforcements for the completion of a DRL schedule in a two-element chain consisting of a response to a touch button followed by the licking of a dry dipper. These investigators report that DRL performance up to a maximum of 120 sec on the touch button was maintained by a single lick-contingent ESB reinforcement.

These later studies would indicate,

therefore, that a two-element chain maintained by multiple ESB reinforcements is not a necessary condition in comparing ESB with conventional reinforcers. To investigate this generalization further, an experiment was conducted to determine if a DRL 30-sec schedule could be maintained in a free operant situation with a single ESB as the reinforcer.

METHOD

Two Holtzman male albino rats were implanted unilaterally (Pellegrino & Cushman, 1967) with stainless steel monopolar electrodes in the region of the lateral hypothalamus (1.4 mm posterior to bregma, 1.6 mm lateral to the midline, and 8.9 mm deep as measured from the top of the brain). The electrodes were insulated except at the tip and after implantation were affixed to the skull by means of dental cement. A single 0.5-sec train of 60-cycle alternating current constituted the ESB reinforcement. An operant conditioning chamber, 9½ x 18½ x 18 in., with a single response lever mounted on the front wall, was used. Both Ss were maintained on ad lib food and water throughout the experiment.

At least a week following surgery, both Ss were screened for self-stimulation and the current intensity, supportive of barpressing, was established. The Ss were then allowed approximately 250 continuously reinforced responses. In the next session, the DRL contingency was instituted. The duration of the DRL was increased from 3 to 30 sec over a 3-day period at such a rate as to permit a rapid attainment of the terminal duration while maintaining responding without excessively long pauses. Each S then experienced the DRL 30-sec schedule, with every correct response reinforced by a single ESB reinforcement, for 10 days.

Throughout the DRL training, the number of reinforced responses and the number of errors (responses with an interresponse time of less than the DRL value) were recorded. Cumulative records were also tabulated. Each daily DRL session was lengthy, with a mean session length of 7.5 h.

RESULTS AND DISCUSSION

Table 1 indicates the mean in blocks

Table 1
Mean of Both Ss Over 2-Day Blocks for the Three Response Measures

Days	Responses Per Reinforcement	Reinforced Responses Per Minute	Percent Reinforcements Obtained
1-2	2.70	1.07	53.17
3-4	2.02	1.15	57.50
5-6	1.64	1.28	63.75
7-8	1.50	1.35	67.50
9-10	1.63	1.38	69.25

Fig. 1. Cumulative records of one S during DRL pretraining, initial DRL 30-sec, and terminal DRL 30-sec training.

of 2 days for both Ss for the three performance measures: responses per reinforcement, reinforced responses per minute, and percentage of possible reinforcements obtained. Considering the first and second response measures, optimal DRL 30-sec performance would require one response per reinforcement and two reinforced responses per minute. For responses per reinforcement a level of 1.63 was obtained, while for reinforced responses per minute the terminal level was 1.38 on the 10th DRL training day. The reliability of the DRL performance is further indicated by the third response measure. Here a gradual increase, over days, in the percentage of possible reinforcements that were obtained is evident, with a terminal performance level of approximately 70%.

Figure 1 presents sample cumulative records of one S taken on the

pretraining days (DRL 3 sec, DRL 5 sec, DRL 15 sec, and DRL 20 sec) and on the first and last days of DRL 30-sec training, labeled 30" and 30", respectively. It can be seen that during pretraining, the response rate became more stable and decreased as the DRL requirement was increased. Likewise, when the final DRL 30-sec cumulative record is considered, the stability and efficiency of the responding is evident. The cumulative records for the second S were similar in all respects to the records presented in Fig. 1.

The present study has demonstrated, therefore, that rats will learn and stabilize on a DRL schedule when the behavior is maintained on a one-element chain by a single ESB reinforcement. The locus of the difference between previously reported findings and the results of the present investigation is unclear. One

possibility, however, is that previous investigators have designed experiments with the idea that an ESB reinforcement must be modified (e.g., multiplied, terminating a chain, etc.) in order to approximate closely a conventional reinforcement. The results of the present investigation, while extending the work of Brown & Trowill (1970) and Owens & Brown (1968), imply that multielement behavioral chains terminating in multiple ESB reinforcements are not necessary for the examination of the comparability of ESB and conventional reinforcers.

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