The effect of intertrial interval on running performance for ESB¹

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Shifting intertrial interval (ITI) from 60 sec to 5 sec or from 5 sec to 60 sec led to corresponding changes in running time for ESB. The eventual convergence of running speeds to preshift levels in many Ss suggests that the changes in running speed with shifts in ITI can be more adequately explained in terms of an incentive rather than a drive decay formulation.

Gallistel (1966) demonstrated that the speed of traversing a runway for rewarding electrical stimulation of the brain (ESB) is inversely related to the interval between successive trials. This was interpreted as evidence for Deutsch's (1963) drive-induction theory of ESB-based behavior. Motivation was assumed to dissipate more with long intertrial intervals (ITI) than with short ones. In a further study Gallistel (1967) showed that increasing ITI from 5 sec to 60 sec increases running speed of water-deprived rats running for water but decreases running speed when animals are running for ESB. Special emphasis was placed on the fact that the shift in running speed occurred on the first trial in ESB-rewarded animals. The following experiment was designed to further study the effects Gallistel reported.

METHOD

Subjects

Ten male Charles River albino rats were implanted unilaterally with stainless steel bipolar electrodes aimed at the medial forebrain bundle and lateral hypothalamus. Each pole of an electrode was 0.23 mm in diameter and insulated except at the tip. Histological verification of the placements were made after testing.

All Ss had been previously used in a study in which they were given continuously reinforced bar press training for ESB and extinction. During the present experiment Ss were maintained on an ad libitum food and water schedule.

Apparatus

Tests were run in a 56 in. long straight runway. A clock was started when a photobeam 13 in. from the back wall of the start compartment was broken. The clock was stopped and brain stimulation was delivered when a metal plate connected to a touch sensing circuit was licked in the goal compartment (the last 9 in. of the runway, separated from the runway proper by a sliding partition). The ESB consisted of .5 sec of 60-cycle sine-wave current. Current intensities which had maintained stable bar pressing were used in the present study. Since Ss were permitted 15 sec in the goal box from the time of the first lick and since they typically licked for the full 15 sec, they usually received approximately 30 bursts of brain stimulation.

Procedure

The Ss were shaped to traverse the runway by permitting them to lick for ESB in the goal compartment and then placing them a short distance from the cup. This distance was gradually increased until Ss reliably ran from the start compartment. When Ss entered the goal compartment the partition was closed behind it.

After shaping, Ss were divided into two groups. One was initially run with an ITI of 60 sec and was later shifted to an ITI of 5 sec (Group 60-5), while the other received the reverse treatment (Group 5-60). Fifteen trials were run each day. If a S did not run within 2 min, it was placed in the goal

compartment and given ESB for 10 sec. For the 60 sec ITI, the animals were removed from the goal box and placed in a metal cage for 55 sec, after which they were placed in the start box, a procedure timed to take 5 sec. Five sec ITI animals were taken from the goal compartment and placed into the start compartment, a procedure also timed to take 5 sec.

The Ss were permitted to run with the initial ITI until they showed five days of latency scores which did not significantly differ from each other. When this occurred they were given, on the following day, five trials with the original ITI and 10 with the new ITI. Four more days of 15 trials per day with the postshift ITI were given.

RESULTS

The mean running times for this experiment are reviewed in Fig. 1. In calculating daily data points the highest three scores of each daily session (except Session 6) were discarded. Most of these scores came from the initial trials of each session and probably represented a warming up effect that is often found in animals running for ESB. This warm-up effect is strikingly present in the trial by trial curve for the ITI shift day (Day 6). During each of the five preshift days Group 60-5 ran significantly ($p < .05$, Mann Whitney U Test) slower than Group 5-60. On Day 6, when ITI was shifted, performance quickly changed to the appropriate level for the new ITI. Full adjustment to the shift usually required two trials. It is striking though that the first postshift trial in both groups was considerably slower than the baseline for the respective ITIs. In fact, for both groups, the first trial running time is significantly slower than the running time for the nine succeeding trials ($ps = .031$, sign test). The last four postshift days show a convergence of running speeds for the two groups. The difference between groups on Days 8 and 10 does not reach significance ($ps > .1$ and $.4$, respectively, Mann Whitney U Test).

To clarify what is happening in the mean curve, individual postshift running latencies were calculated as per cent of pre-shift performance (Fig. 2). The postshift topography shows considerable between-S variability. In Group 60-5 three Ss (S-2, S-4, S-5) show a significant increase in running time from Day 6 to Day 10 ($ps < .02$, sign test). S-3 shows an increase in running time on the first postshift day, which decreases during

Fig. 1. Mean latencies of traversing a runway to obtain ESB under either 60 sec or 5 sec ITI during training (Preshift) and during the reversal of ITI (Postshift). Trial by Trial scores are presented for the day of the shift (Day 6). Unconnected data points on Trial 6-Day 6 and Day 10 are unrepresentative means that include the deviant scores of one S.

Fig. 2. Individual postshift latencies as per cent of preshift response level. Solid black dot after S number indicates that animal required priming at the start of sessions.

the next two days, and then again recovers. S-1 shows a consistent decrease in running time for the duration of postshift testing.

Similar regression toward baseline during the postshift period occurs in Group 5-60. In S-7 and S-9 running times are significantly higher on Day 6 than on Day 10 ($p < .02$, sign test). S-6 shows a decrease in running time on the first day followed by an increase which returns to baseline over the next three days. S-8 and S-10 showed no statistically significant recovery of running speed.

DISCUSSION

The comparability of the present data and that presented by Gallistel (1967) is difficult since no Trial by Trial, nor Day by Day data was presented in that study. The initial effect of shifting ITI from long to short, or from short to long, on latency of running essentially replicates Gallistel's results. The postshift convergence that occurred in many of our Ss, however, was not reported by Gallistel and is difficult to explain in terms of drive-decay theory. The data of S-6 and S-7 are especially compelling. Both Ss had faster running speeds on several days with 60 sec ITIs than the mean 5 sec ITI level. Likewise S-3, S-4, and S-5 had sessions during which running speeds were slower at the 5 sec postshift ITI than they had been at the 60 sec ITI baseline. Scott (1967) has furthermore shown that rats run well for ESB even with 15 min ITIs, and that well-trained Ss do not show overnight decrements in responding.

Gallistel's (1967) conclusions are primarily based on the fact that the shift in running speed with shift of ITI occurs on the first postshift trial. In our data, this immediate shift is also present during the first trial of Group 5-60. In fact, however, animals had such a depressed running latency on this trial that it is significantly different from the latencies of the remaining trials of the session, during which running latencies quickly returned to baseline levels. The first postshift trial in our data then would also support a drive-decay hypothesis, but viewed in conjunction with the remaining trials such support would be at best misleading.

We feel that the differential running speeds with long and short ITIs reflect the operation of an underlying incentive process that interacts with drive level. It is hypothesized that the failure of increasing ITI to depress response speed in water-deprived animals running to water (Gallistel, 1967) is due to the interaction of ITI and drive level. The present formulation would predict that animals at low drive levels running for appropriate high incentive rewards will also show the differential running speed as shown by animals running for ESB.

Bindra (1968) has proposed that the facilitation of instrumental responses is not caused by drive itself, but by an "increase in the efficacy of incentive motivational stimuli [p. 1]." Similarly, we would predict that high incentive substances are capable of increasing activity of animals at low deprivation levels. Observations of nondeprived animals working for a high incentive chocolate milk solution supports this proposition (Panksepp & Trowill, 1967). Quartermain & Webster (1968) have also presented evidence for a persistent increase in activity level after a bout of self-stimulation. In other words an unconditional response to a high incentive substance is activity. General activity is furthermore correlated with arousal (Bindra, 1968). The dissipation of motivation after self-stimulation may then merely reflect a decrease in arousal level. Hence, in the present experiment, a long ITI is hypothesized to lead to slow running latencies because of the lower ambient activity level at the start of the trial. On the other hand, maintained arousal during a natural deprivation state is sufficient to maintain rapid instrumental performance despite long ITIs. Finally, the gradual decrease in latency across sessions observed in the 60 sec ITI group suggests that an additional factor independent of unconditional activity level, such as further learning, is operating to improve performance. One possibility is that the gradual conditioning of the cues of the situation are now able to elicit increased activity levels as proposed by Bindra (1968). In more anthropomorphic terms it could be said that the animal is developing an expectancy and that this expectancy is being translated into improved performance by an increased activity level. A more thorough development of the incentive viewpoint for ESB-based behavior has recently been presented by Trowill, Panksepp, & Gendelman (in press).

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NOTE

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