DECREMENT IN PERFORMANCE DURING PROLONGED AVOIDANCE SESSIONS

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The purpose of this experiment was to study some effects of forcing an animal to make a simple operant response over extremely long periods of time. The experiment may be considered within the general context of fatigue or sleep deprivation. In order to maintain responding, an avoidance technique was used. The selection was made for several reasons: first, the avoidance procedure generally produces a number of responses per minute so that the animal has little opportunity for rest; second, a failure to respond results in an aversive stimulus which awakens a sleepy animal and reinstates responding; and third, avoidance behavior is not subject to satiation effects which are difficult to control during long exposures to positive-reinforcement schedules. The consequences of the extended period of responding were evaluated from the avoidance behavior in terms of response rate and shock frequency. In addition, a fixed-interval schedule of reinforcement was occasionally introduced into the procedure, and thus allowed measurement not only of the response rate but also of the temporal discrimination which typifies this schedule.

SUBJECTS AND APPARATUS

The subjects were two male Rhesus monkeys. Under the deprivation procedure used, one monkey (L) weighed approximately 8 kilograms while the other (V) weighed about 3 kilograms. The past history of both monkeys was composed of lengthy training (more than 1500 hours) on a multiple schedule with avoidance, S^A , and fixed-interval components.

The experimental chamber was a metal box, 2 feet in each dimension, containing a micro-switch lever and a motor-driven dipper. The bottom and one side of the chamber were formed of grids.

An electric shock could be delivered to the animal through the grids by means of a scrambler which randomly reversed the polarity of the voltage on the grids. The motor-driven dipper presented about 0.75 milliliter of condensed milk through a small opening. The procedure was programmed automatically by a system of relays and timers, while the lever-pressing behavior was recorded on magnetic counters and a cumulative recorder.

PROCEDURE

Preliminary Studies

Pilot experiments were run in which the monkeys were kept mainly on the avoidance procedure for sessions of moderate durations. Sessions of 3 and 5 days were first tried. In view of these experiments, which showed that the monkeys could tolerate the long sessions without great difficulty, the week-long sessions described below were tried. The data gathered in the shorter pilot experiments were consistent with those reported below for the week-long sessions.

The monkeys were maintained on a feeding regime of one meal every 2 days. The meal consisted of one and a half oranges, half a head of lettuce, and an excess of Purina monkey chow pellets. Left-over food was removed after an eating period of 2.5 hours.

The procedure during the experimental sessions consisted of a multiple schedule with two components, free-operant avoidance (Sidman, 1953) and a fixed-interval schedule of reinforcement (Ferster & Skinner, 1957). During the avoidance procedure, a 5-milliamper shock was delivered every 20 seconds in the event the animal did not press the lever (shock-shock interval equals 20 seconds); each lever press postponed the shock for 20 seconds (response-shock interval equals 20 seconds). During the avoidance procedure, an auditory clicker was presented through a loud-speaker in the chamber. In the absence of any auditory stimuli, a 5-minute, fixed-interval (FI) schedule of reinforcement was programmed: the first response after 5 minutes was reinforced with the presentation of a dipper of condensed milk for 5 seconds.

During the prolonged sessions, the basic aim of the experiment was to keep the animal responding predominantly on the avoidance procedure for 7 days. Avoidance was interrupted only for a feeding period every 2 days or for occasional daily tests of FI behavior. The details of each daily schedule were as follows. A monkey was put into the chamber on a Friday afternoon at about 4:00 p.m. having been fed the previous day. Three to six FI's were run off, after which the avoidance procedure was turned on until 9:00 a.m. Saturday morning. Then, for about 2.5 hours, the procedure was changed to an alternation of three FI's and 15 minutes of avoidance. A shifting limited-hold procedure was used with the FI schedule so that a failure to respond after 5 minutes would cut short the FI component and produce the avoidance component again. To facilitate getting at least a partial sample of FI behavior, the limited hold on the first FI was 45 seconds; on the second, it was 30 seconds; and on the third, 15 seconds. In this way the animal was prevented from taking a long rest during the FI periods. After about 2.5 hours of alternating avoidance and FI, the S^A (a tone) was turned on, and the daily ration was put in the experimental chamber. As soon as the animal was observed to have stopped eating (usually after an hour or so), the surplus food was removed and the avoidance procedure was reinstated. At 8:00 a.m. Monday, the alternating FI avoidance procedure was instituted for 4 hours, the animal was fed, and avoidance was run for 2 hours; then, the alternating FI avoidance was run for about 1 hour until 4:00 p.m., when the straight avoidance was allowed to remain on until 8:00 a.m. the next day. The programs for Wednesday and Friday were the same as those for Monday. The programs for Tuesday and Thursday were the same as those for Monday, except that an avoidance period replaced the feeding period.

Following a session, the monkey was given a week of rest with normal rations in the home cage in order to minimize carry-over effects from one session to the next. Each monkey participated in three of the prolonged sessions as described above over a 6-week period. Due to technical difficulties, however, the data for one session for Monkey V were discarded.

RESULTS AND DISCUSSION

The average rate of avoidance responding (in lever presses per minute) and the shock frequency (in shocks per 10 minutes) were calculated for each day and night of the experiment, with the exception that one average rate was calculated for the continuous-avoidance period from Saturday noon to Monday morning. The average rates during the fixed-interval schedule were also measured for the appropriate days.

Figures 1 and 2 show how the above measures changed during the week-long session. The average of three sessions for Monkey L are described in Fig. 1, while the average of two sessions for Monkey V are in Fig. 2. A generalization can be made about all sessions for

Figure 1. Changes in response rates and shock frequency during the prolonged sessions (Monkey L). The points are the average of three sessions.

both monkeys: as the sessions progressed, the avoidance rate decreased and the shock frequency increased. After the fourth day, the avoidance behavior at night differed systematically from that in the day; thus, the curves for avoidance rate and shock frequency assumed a systematic zig-zag appearance. The most likely possibility is that the day-night difference represents a typical diurnal cycle; however, the insertion of the fixed-interval schedule and the feeding period during the day might have contributed to the difference. The avoidance rate and the shock frequency returned to their normal values at the beginning of each session after the animals had been in their home cage for a week.

The fixed-interval rate also declined through the session except for a small rise toward the end of the session. This slight rise, which occurred in four of the five sessions studied, may represent an increase in "drive." That is, a long avoidance session which requires sustained performance may produce changes in food-reinforced behavior similar to food-deprivation operations. In support of this interpretation was the fact that the animals lost weight during the extended session.

Figure 2. Changes in response rates and shock frequency during the extended sessions (Monkey V). The points are an average for two sessions.

A more specific picture of changes in avoidance behavior may be seen in Fig. 3. Samples of Monkey V's cumulative record of Session 134 were selected from the first, the fourth, and the seventh nights. The record for the first night shows the rested monkey putting out a relatively high steady rate and taking few shocks. By the fourth night, however, the average rate is lower, the shocks are more frequent, and a cyclical pattern emerges. The rate slows gradually to the point where a shock is delivered. After the shock, the rate increases abruptly and then slows again to start another cycle. It is attractive to consider the cyclical pattern as a behavioral picture of "dozing." By the seventh night, the rate is quite low and the number of shocks is extremely high.

In Fig. 4, a picture of the fixed-interval behavior is shown at various days during the session. Since the fixed-interval behavior varied considerably, the records selected for this figure are not representative of all patterns which appeared during the session. In general, however, remarkably few changes occurred.

Disruption of the characteristic fixed-interval scallop was not observed, even at the end of the session. The lack of a major change in this study is consistent with the finding of Skinner and Morse (1958), who kept pigeons responding over long periods by a DRL schedule. The only clear change in the FI seemed to be in the frequency of "flat" scallops; that is, as the session progressed, scallops with only one response or even no response (where the limited-hold procedure terminated the FI) occurred more frequently.

Figure 3. Changes in avoidance behavior during the course of the prolonged session. The pips on the cumulative record indicate shocks.

Figure 4 also illustrates another point. At all times during the session, the animal's ability to discriminate between the stimuli for avoidance and fixed interval was unimpaired. It might be expected that the avoidance rate of a sleepy animal would run through into the first minutes of the next fixed interval. However, as may be seen in Fig. 4, when the stimuli changed from avoidance to fixed interval, the monkey stopped responding immediately.

Figure 4. Alternating fixed-interval avoidance behavior at various days in the session. Three FI's are followed by 15 minutes of avoidance which in turn is followed by three FI's. The pips mark reinforcements during the FI period and shocks during the avoidance period. In addition, a pip was made at the moment the avoidance procedure ended.

Observation of the animals during the extended session revealed several points of interest: 1) a monkey can appear to be asleep (eyes closed, hunched into the typical sleep posture) and still maintain a steady rate of avoidance responding; 2) monkeys appear to catch quick "naps" and then "awaken" to make lever-pressing responses. For example, in the first seconds after an avoidance response, the animal might assume the sleep posture; then, the animal would abruptly "awaken" and make an avoidance response. A similar observation was often made during the first minutes of the fixed-interval schedule. If a technique could be found which would eliminate these quick "naps," it is possible that decrements in performance would be observed in considerably less than 4-5 days.

SUMMARY

Two monkeys, previously trained to lever press on a multiple schedule of avoidance and fixed-interval reinforcement, were subjects in an experiment to determine the decrement in

performance generated by a prolonged session. The monkeys were kept predominantly on a Sidman avoidance procedure for 7 days, during which they were required to respond at least once every 20 seconds. Changes in performance occurred slowly and gradually, but after 4 days rather clear effects could be seen. The rate of avoidance responding decreased and the number of shocks increased sharply. The fixed-interval rate tended to decrease, although in some cases a small increase was observed late in the session. The temporal pattern of the FI scallop was not disrupted by the long session, although small "flat" scallops occurred more frequently. The animals' stimulus discriminations were unimpaired.

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