EFFECTS OF DEPRIVATION UPON COUNTING AND TIMING IN RATS

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Two procedures were used in an investigation of the effects of deprivation upon counting and timing. Under the first procedure, fixed minimum interval (FMI), the rat received liquid reinforcement every time it pressed bar B after having waited a minimum of 5 sec following a press on bar A. Under the second procedure, fixed consecutive number (FCN), reinforcement was delivered every time the rat pressed bar B following a run of at least four consecutive responses on bar A.

Water deprivation was varied over a set of values ranging from 4 to 56 hr. Deprivation had almost no effect on the waiting time in the FMI procedure, or on the number of responses per run in the FCN procedure. With both procedures, increasing deprivation shortened the pause between reinforcement and the next response. In the FCN procedure, the speed with which the runs were executed increased with increasing deprivation, although the number of responses in these runs was relatively unaffected.

The purpose of this study was to determine the effects of liquid deprivation upon the stabilized performances that rats develop under a counting procedure (Mechner, 1958) and a temporal discrimination procedure (Mechner & Latranyi, 1960; Mechner, Snapper, & Ray, 1960).

METHOD

Apparatus

Two rat rotors were used as the testing chambers. The rat rotor is a device which cycles rats through a testing station automatically and continuously without daily human attendance. It consists of a set of eight trapezoid-shaped cages, circularly arranged on a turntable, with a rat permanently stationed in each. When a rat is opposite the testing station, it has access to two bars and to the cup of a liquid reinforcement dispenser, which delivers about 0.03 ml at each presentation. The animal can see a stimulus light through another hole. At the end of a work session, the entire turntable indexes one position, so that the next rat is opposite the testing station. In the back of each cage is a solenoid-controlled window with a water bottle behind it. This

window can be lifted at any time by remote control so that the animal has free access to the water supply. The animal may be given access to a food supply through an adjacent window.

Subjects

The subjects were 11 male albino rats of Charles River stock, about 10 mo old at the beginning of the experiment. Immediately preceding the experiment, they had spent 7 mo in the same rat rotors used in the experiment, earning their subsistence under essentially the same conditions as those described below.

Procedure

Seven rats were assigned to the counting procedure, called the fixed consecutive number (FCN), and four to the timing procedure, called the fixed minimum interval (FMI). Under the FMI procedure, the rat was required to press bar A (response R_A) and then wait a minimum of 5 sec before pressing bar B (R_B). If the animal made R_B before 5 sec had elapsed, it had to start over with a new R_A . Under the FCN procedure, at least four consecutive R_A 's were required before an R_B could be reinforced. Again, if R_B occurred before four consecutive R_A 's had been completed, the rat had to start over. Each procedure was administered in a different rat rotor.

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Each rat came into the testing position for 1 hr every 8 hr. The rats had continuous access to the food supply, and earned their entire daily water allowance (about 10 ml per day) in the experimental sessions. Under this regimen, they gained weight and remained healthy for their entire 12-mo experimental careers. At the higher values of deprivation, the same conditions prevailed except that appropriate numbers of sessions were skipped. For the 24-hr deprivation condition, for example, two consecutive 8-hr sessions were skipped. The performance described in the

graphs is based on the first session after the deprivation period. Following a test session, an animal was always given from 3 to 6 days to restabilize on the 8-hr rhythm before the next prolonged deprivation period was initiated. Each animal was subjected to each level of deprivation three times during the experiment. The order of deprivation conditions was always unsystematic.

Behavioral Measures

For the FMI procedure, three measures were examined: (1) The average time interval

Fig. 1. Effects of deprivation upon waiting time and postreinforcement pause in a temporal discrimination procedure. Each of the four columns of graphs represents the data for one rat.

the animal actually waited between R_A and R_B (normally very close to the required 5 sec); (2) the standard deviation of the distribution of waiting times (usually about one-tenth of the average waiting time); and (3) the average postreinforcement pause, measured from the end of the reinforcement presentation to the following R_A .

For the FCN procedure, five measures were examined: (1) The average run length (number of consecutive R_A 's made before R_B), (2) the standard deviation of the distribution of run lengths (usually about 20 per cent of the average run length), (3) the average run duration, defined as the time between the first R_A of the run and the next R_B , (4) the standard deviation of the distribution of run durations (usually between 30 and 50 per cent of the average run duration); and (5) the average postreinforcement pause, defined as the time from the end of the reinforcement presentation to the following R_A .

RESULTS

Every point in the figures represents the mean of three determinations except for three points: the 4-hr deprivation in the FCN experiment, based on single determinations; the 56-hr deprivation in the FMI experiment, also based on single determinations; and the 8-hr deprivation in both experiments, representing the average of 15 determinations. Analysis of variance revealed no significant differences among the three replications for any of the 11 rats.

The upper row of graphs in Fig. 1 shows that the means and standard deviations of the waiting time distributions in the FMI procedure are only slightly influenced by level of deprivation. The slight trends discernible in individual animals are significant by analysis of variance, but they differ in direction from one animal to the next. On the other hand, the effect of deprivation upon the postreinforcement pause is very marked, and is in the same direction for all four subjects. The higher the level of deprivation, the shorter the pause.

The findings are generally the same with the FCN procedure (Fig. 2). The effects of deprivation upon the means and standard deviations of the run length distributions are comparatively small; and, although the direction of the effects is statistically significant for individual animals, it is again inconsistent from one

animal to the next. The postreinforcement pause is again strongly affected, becoming shorter with increasing levels of deprivation for all seven rats. Except for Rat C2, increasing deprivation always produced a shortening of run duration and a roughly proportional decrease in the standard deviation.

DISCUSSION

In 1958, Conrad, Sidman, and Herrnstein showed that inter-response time under differential reinforcement of low rates is inversely related to deprivation. Although this seems contradictory to the present findings, it is actually consistent. Under differential reinforcement of low rates, the postreinforcement pause and the temporal discrimination pause are merged into a single measure. The present study shows that the postreinforcement pause is strongly affected by deprivation, whereas the R_A - R_B interval, which is the time discrimination pause, is not. If these two pauses were merged, the result would be consistent with the findings of Conrad *et al.*

The fact that the time discrimination pause is minimally affected by deprivation is also interesting from the psychopharmacological point of view. In drug experiments by Mechner and Latranyi (1960), methamphetamine, methylphenidate, and caffeine were found to shorten this pause markedly. It has sometimes been said that the behavioral effects of these drugs are "drive-like" or "motivational." The present findings indicate that the behavioral effects of deprivation are very different from those produced by these drugs.

Under the FCN procedure, the run length was relatively insensitive to deprivation, whereas run duration and postreinforcement pauses were strongly affected. These results, when taken together with those obtained under the FMI procedure, suggest a tentative generalization. Every behavioral procedure has at least one dimension along which the requirement for reinforcement is defined. For FMI, this dimension is the waiting time between R_A and R_B ; for FCN, it is the run length. Every behavioral procedure also has a number of dimensions which are irrelevant to the reinforcement requirement. Among these are the postreinforcement pause and, for FCN, the run duration. All the results presented in this paper are consistent with the interpretation that deprivation level has no

Fig. 2. Effects of deprivation upon number of responses per run, run duration, and postreinforcement pause in a counting procedure. Each of the seven columns of graphs represents the data for one rat.

effect upon the measure taken along the dimension in which the reinforcement requirement is defined. On the other hand, deprivation affects quite strongly measures taken along other dimensions, the effect being always in the direction of an increase in speed.

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