CONTINUOUS OPPORTUNITY FOR REINFORCING BRAIN STIMULATION¹

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The performance of a rat provided with continuous opportunity to obtain reinforcing brain stimulation over a 20-day period is described in detail. The animal averaged 29.2 responses per min during the entire time. Testing session was terminated by experimenters, but a day-by-day analysis of behavior provided no evidence that the animal would have stopped responding.

A number of references have been made in the popular press to the performance of a rat that had continuous opportunity to obtain reinforcing brain stimulation over a 20-day period (Brecher and Brecher, 1961; Coughlan, 1963). There has been no accurate or complete record published of the performance of this animal. It is thus desirable to make this information available in view of the recent interest in brain stimulation as a possible reinforcer for prolonged studies of performance. On February 9, 1960, a male rat weighing 444 g was placed into a 18 by 12 by 12 in. testing chamber. A lever at one end of the chamber provided the animal with a 0.5 sec train of brain stimulation for each lever response. The stimulating current consisted of biphasic, rectangular pulses with a duration and interpulse interval of 0.2 msec. Pulse-pair frequency was 100/sec and current intensity was 0.4 ma. Based on previous experience with the animal this current intensity was judged to yield maximal response rates. The bipolar electrode assembly and implantation technique have been described in detail elsewhere (Valenstein, Hodos and Stein, 1961). A slip-ring assembly was used to prevent cable twisting. Diluted condensed milk reinforced with Polyvisol was available at all times. The testing room was entered only to change the milk twice daily and on two additional occasions to repair equipment. The rat was left in

the chamber 21 days, but on the last day the brain stimulator was turned off in order to obtain a record during extinction.

A print-out counter recorded the total lever pressing responses during each 5-min period. The non-responding time was based on the 5-min periods in which no responses occurred.

Fig. 1. Day-by-day analysis of data. (A) Equipment failure eliminated stimulation opportunity for 959 min. (B) Broken cable eliminated stimulation opportunity for 502 min. (C) Current intensity raised 50%. (D) Extinction (stimulator turned off).

During the 20 stimulation days the total responses were 842,130. Daily response totals averaged 42,106 (range: 25,811-93,712). Figure 1 presents a day-by-day analysis of the average responses per minute, non-responding time and average response rate based on total minutes less the non-responding time. On days 11 and 13, equipment failures during the night resulted in long periods without reinforcement. Following these interruptions the total responses increased on the next day (c.f., Fig. 1). As performance appeared to be

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stable by day 18, the current intensity was increased 50%. This was followed by an increase in total responses due primarily to a decrease in non-responding time. At the beginning of day 21 the stimulator was turned off and the total responses on this day was only 223 and the total non-responding time was 1429 min (99.2% of the day). As only one response during a 5-min block eliminated that period from the total non-responding time, it is evident that when the animal stopped responding it seldom returned to the lever.

An analysis of consecutive 5-min periods during the 20 stimulation days revealed the following distribution of long intervals in which there were no responses: 1.5-2 hr (10 periods); 2-2.5 hr (5 periods); 2.5-3 hr (3 periods); and 5-5.5 hr (1 period). These figures do not include the two periods attributable to equipment failures. Eleven of these 19 periods occurred during the first 10 days and eight during the second. The distribution of the non-responding time from day 3 through day 10 gave the following evidence of a diurnal rhythm: 17.7% of total non-responding time occurred between the hours of 0800-1200; 22.1% between 1200-1600; 21.1% between 1600-2000; 15.5% between 2000-2400; 12.6% between 2400-0400; and 10.6% between 0400-0800. Days 3 to 10 were selected for analysis as the animal's response rate during the first two days was significantly above average. An equipment failure invalidated the data for day 11. This evidence for a persisting diurnal rhythm in self-stimulation performance is of special interest in view of the fact that the lights in the test chamber remained on during the entire experiment.

The session was terminated before any evidence that the rat would have stopped responding if testing were continued. Although not under constant observation, the animal was never observed to do anything but lever press while awake, with the exception of brief breaks to eat and preen. Characteristically, the animal slept directly under the lever and was observed to start lever pressing immediately upon awakening. At the end of the experiment the animal weighed 403 g, or 91% of its weight at the start of testing.

Histological examination located the tip of the electrode in the lateral hypothalamus at the frontal plane of the nuclei dorsomedialis and ventromedialis hypothalami. Coordinates for this location in the atlas of de Groot (1959) are: A 5.0; L 2.25; D— 2.50.

Previous to this session the authors tested another rat with a hypothalamic electrode with identical conditions to those described above, except that the experiment was terminated after five days. This animal made 164,608 responses (average rate: 22.9 responses per min) during this period. Effect of a diurnal rhythm was also evident in the distribution of non-responding time of this animal. During the 12-hr periods from 1800-0600 only 39% of the total non-responding time was accumulated during days 2 through 5. Although the data were not collected for identical time periods, as with the animal tested for 21 days, it is apparent that with both animals there were fewer periods of inactivity during the night and early morning than during an equivalent time during the late morning and afternoon. In other respects the behavior was as reported for the 21-day animal. It is not possible, however, to conclude that results would be similar with all reinforcing electrode placements. Indeed, based on preliminary data we are inclined to agree with Olds (1958) that the behavior of animals with electrodes in the septal nucleus might not be as resistant to satiation.

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