Appetitive thresholds of the hypothalamic "feeding area" self-determined in the rat

B. P. H. POSCHEL

PARKE, DAVIS & COMPANY, RESEARCH DIVISION, ANN ARBOR, MICHIGAN

Increasing intensities of electrical stimulation were delivered to the "feeding area" of the lateral hypothalamus of unrestrained rats. The animals could lick a tube to obtain milk or water. Licking the tube also operated a drinkometer which reduced the intensity of the brain stimulation. Thresholds of centrally-elicited "hunger" and "thirst" were thereby continuously estimated. Performance depended upon the availability of food or water.

Electrical stimulation of the "feeding area" of the lateral hypothalamus will cause a satiated animal to eat or to drink (Andersson & McCann, 1955; Larsson, 1954). Moreover, electrical stimulation of this area will motivate satiated animals to perform old habits instrumental in obtaining food or water (Andersson & Wyrwicka, 1957; Miller, 1957), or even to learn new habits instrumental in obtaining food (Mendelson & Chorover, 1965). However, in these and all related studies, the intensity of the electrical brain stimulus was fixed by the experimenter. Consequently, two basic questions in this area remain uninvestigated. Can the intensity of stimulation delivered to the "feeding area" be made quantitatively dependent on the animal's behavior, as in a "titration" self-adjustment situation? Will such "titration" depend upon the procurement of food and water, or merely upon the fractional reductions of the intensity of the brain stimulus as occurs in the case of ambivalent brain areas (cf. Poschel & Ninteman, 1965)?

Method

Monopolar electrodes were implanted in the "feeding area" of the lateral hypothalamus of 20 adult male albino rats. The electrodes were made of 30-gauge platinum wire, with 0.5 mm at the tip bared of insulation. About 14 days after surgery, the animals were given preliminary tests for stimulus-bound feeding and drinking reactions. In these tests the experimenter slowly raised the intensity of the electrical brain stimulus, while food pellets and a water bottle were freely available to the animal. About seven days later these tests were repeated. Nine successfully implanted

rats were found: six which ate, two which drank, and one which both ate and drank, when stimulated.

The titration tests were conducted in a chamber equipped with a metal drinking tube and drinkometer. The drinkometer operated through a circuit breaker which interrupted the circuit six times per sec., the approximate rate at which rats lick. This arrangement assured pulsed signals from the circuit even if the rats maintained continuous contact with the tube while licking. At the start of each test, a rat was placed into the chamber and allowed to satiate itself on milk or water from the drinking tube. Then electrical stimulation (sine wave, 60 cps) was continuously applied to the rat's electrode, starting at a low intensity. Every 1 min. the current intensity was raised one step by advancing a two-way stepping relay. If no licking of the tube occurred, the maximum stimulus was reached in 25 approximately equal steps. Every 33 licks, however, reduced the stimulus intensity by one step. Thus, the intensity of the brain stimulus was regulated solely by the rat's contact with the drinking tube. The stimulus levels maintained were recorded graphically by a two-way recorder.

Each animal received at least five titration tests, at least 40 min. long, usually seven days apart. The drinkometer bottle contained undiluted Carnation evaporated milk for the six rats which ate food in the preliminary tests, while tap water was used with the three rats which drank water. However, on one occasion, usually during a S's last test, the drinkometer bottle was empty. (An empty bottle did not hinder the operation of the drinkometer.) This test was terminated when the brain stimulus reached maximum intensity, or when the rat showed agitation incompatible with licking. Ultimately, electrode placements were confirmed histologically.

Results

Graphic records from a representative S, run on water, are presented in Fig. 1. Figure 1A shows the programmed rate of increase of the brain stimulus if

Fig. 1. Appetitive titration records of rat 1, run on water. Records read from right to left.

Table 1. Maximum Intensity of Stimulation Rats
"Tolerated" with and without Incentive Present

Rat	Type of incentive	Incentive present (μ a)	Empty bottle (μ a)
1	water	33.1	70.4
2	water	21.4	60.4
3	water	17.8	42.8
4	milk	21.4	62.7
5	milk	30.3	73.2
6	milk	30.3	73.2
7	milk	23.8	62.7
8	milk	22.4	73.2
9	milk	22.4	73.2

Note - Maximum intensity possible was 73.2 μ a.

no drinking occurred. Figure 1B shows the rat's behavior in the fourth titration session. The record shows low variability and a well-defined threshold, although there is a slight increase in threshold during the first half of the test; thereafter, the threshold undergoes no further change despite the lengthy session. This threshold is recoverable from week to week as indicated by Fig. 1C, which shows the seventh titration session. Figure 1D shows the effect resulting when the drinkometer bottle is empty of water, 5 min. after the preceding test. The record clearly indicates that the incentive is necessary for titration. Thus, this behavior is not reinforced primarily by the fractional reductions of stimulus intensity produced by licking, nor by the act of licking per se, but rather by the sensory stimuli of water. Figure 1E shows that seven days later the rat's baseline is again attainable with water.

Data from all Ss showing the effect of an empty drinkometer bottle are presented in Table 1. Listed is the incentive normally used with each animal, and the peak intensity of stimulation each animal allowed the stepper to reach with the incentive present, and then

absent. The data of the "incentive present" condition are from the tests run most recently prior to the empty bottle tests. Equal time was sampled under the two conditions by equating each pair of titration records on the basis of the length of the empty bottle test. The indicated difference between the two conditions is highly significant ($t=15.92$, $df=8$, $p<.001$).

Discussion

The present type of titration behavior depends upon the procurement of food or water, which clearly shows that the resulting thresholds pertain to the activation of appetitive neural systems. Stimulation of the hypothalamic "feeding area" seems to elicit a central process which an animal discriminates accurately, much like a sensory process. The results support the theoretical notion that this system of the brain subserves the drive-stimulus (or sensory) aspects of hunger and thirst, rather than mere motor systems for feeding and drinking.

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