Lateral hypothalamic reward decreased by intragastric feeding: Self-determined "threshold" technique¹

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Intragastric feeding increased the threshold for lateral hypothalamic reward as measured by a modified self-selected threshold technique. Postingestional lethargy would have had the opposite effect and therefore does not account for the results. This supports the theory that food intake modulates the reward of self-stimulation.

Self-stimulation increases during food deprivation (Margules & Olds, 1962; Wilkinson & Peele, 1962), and decreases following intragastric feeding (Hoebel & Teitelbaum, 1962). In these studies response frequency was used as the measure of reward. It was concluded partly on the basis of this evidence that hunger augments lateral hypothalamic reward, and satiety inhibits it (Hoebel & Teitelbaum, 1962).

There is a possible criticism of rate as a measure of reward. Rats become increasingly active during food deprivation (Campbell, 1964) and lethargic after eating. Self-stimulation rate might, therefore, reflect changes in gross activity level.

Stein & Ray (1960) devised a technique with which an animal can indicate a change in lateral hypothalamic reward without necessarily changing its response rate. This is a modified, self-selected "threshold" procedure designed to measure reward level by allowing the S to partially control its own current intensity. When the S presses a lever to self-stimulate, current available for the next response automatically decreases. The S responds repeatedly until the stimulus diminishes to the point that it is no longer reinforcing, then S indicates this by pressing a second lever which resets the available current to maximum intensity.

Stein (1962) used this technique to measure drug effects. He found that treatments which decreased the rate of fixed-current self-stimulation, increased the proportion of resets in the threshold procedure. Conversely, treatments which increase self-stimulation rate, decrease the proportion of resets. We have used this technique as a control for inactivity when measuring the effect of food intake.

It is important to note that to reset the current the animal must move to a lever which provides no brain stimulation. A sluggish rat that tends to stay in one place will display a decreased proportion of reset responses or stop responding entirely. A rat with diminished hypothalamic reward will increase the proportion of resets to keep the current elevated to

a rewarding level. This procedure therefore separates the effects of inactivity from those of decreased reward.

Method

The Ss were five 260-270 g female, Sherman rats bilaterally implanted with lateral hypothalamic electrodes (Hoebel, 1964). Electrodes were implanted perpendicular to the skull, 2.0 mm lateral to the mid-sagittal sinus, 6.0 mm anterior to the interaural line and 7.5 mm ventral to the surface of the cortex (L 2.0, A 6.0, D 7.5).

The stimulus was a 100 Hz train of 0.1 msec, negative pulses passed through an isolation transformer. All testing was done in a 7 x 12 in. cage with two response levers located 3 in. apart and 1 in. above the floor on one wall. A response on the self-stimulation lever initiated stimulation for 0.5 sec during which time the lever was inactivated. The available current intensity then automatically decreased one step so that the next response would initiate a weaker stimulus. There were 23 equal steps between zero and the maximum current of either .25 mA or .22 mA. A response on the reset lever immediately shifted the available current to maximum intensity without giving stimulation. The maximum current was chosen so as not to exceed the range in which response rate and current are positively correlated.

For each S the average reset level was determined before and after tube feeding on two to five different days. Performance was allowed to stabilize for at least 10 min before each session began and for 10 min after tube feeding. Results were evaluated by comparing the 10 min period immediately before feeding with the second 10 min period afterwards. Ss were tube-fed 10 cc within 1 min. The following solutions were used: 30% or 50% dextrose in tap water (weight/volume), or liquid diet containing 250 ml evaporated milk, 125 ml 50% sucrose, two eggs, and 30 ml of Kaopectate. Ss were also sham fed by applying all the manipulations of tube feeding, but without injecting any food. Between tests they were maintained on ad libitum Purina pellets and water.

Results

Table 1 presents results in the right hand column which show that after tube feeding all experimental Ss decreased the proportion of self-stimulation responses per reset. On the average there were 1.5 fewer self-stimulation responses emitted before a

Table 1 Effect of tube feeding on the proportion of self-stimulations per reset in 10 min periods

Rat and treatment	Self-stim. Resp.		Reset Resp.		Self-stim./Reset	
	Before ¹	After ²	Before ¹	After ²	Before	After
Tube fed Ss						
1-g ³	453	+75	48	+19	9.4	-1.5
1-g	548	-38	64	+ 2	8.6	-0.9
1-g	487	+48	53	+13	9.2	-1.1
1-g	443	-23	69	+29	6.4	-2.1
1-g	472	-34	63	- 1	7.5	-0.4
2-d	597	- 1	41	+ 4	14.6	-1.4
2-G	633	-58	63	+ 7	10.0	-1.8
3-G	623	-20	46	+ 8	13.5	-2.3
3-G	617	-10	45	+ 8	13.7	-2.2
4-dd	700	-108	44	- 2	15.9	-1.8
4-dd	764	-35	48	+ 1	15.9	-1.0
Mean change (experimental)		-19		+ 8		-1.5
Sham fed Ss						
1-s	458	-55	57	- 9	8.0	+0.4
2-s	725	- 5	89	- 0	8.1	-0.1
3-s	696	-79	50	- 5	13.9	-0.2
4-s	656	+70	41	+ 4	16.0	+0.1
Mean change (control)		-17		- 3		+0.1

(1) Total responses in the 10 min period prior to treatment. (2) Change in responses in the second 10 min period after treatment. (3) g=30% glucose, 10 cc, tube fed; G=50% glucose; d=liquid diet; dd=two 10 cc feedings of liquid diet 1.5 h apart with measurements taken before and after the second feeding; s=sham tube fed.

reset response occurred. This is clearly significant since sham feeding never had as large an effect as when food was delivered.

Excluded from Table 1 are the data for one S which self-stimulated only sporadically after tube feeding; the others responded consistently. Their mean self-stimulation rate decreased about as much as the controls, but their mean reset rate increased. The

net result of this shift in response pattern was to maintain higher self-stimulation currents. Lower intensity levels were no longer as reinforcing as they had been before feeding.

Discussion

Tube feeding increased the self-selected "threshold" for self-stimulation. After feeding, when activity normally tends to decrease, the rats in this experiment became more active in pressing the reset lever. Thus the proportion of reset responses increased in spite of possible postingestional lethargy. This provides new evidence that stomach loading reduces the reward of lateral hypothalamic self-stimulation, and strengthens the theory that lateral hypothalamic reward is related to natural rewards of eating (Hoebel, in press).

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Note

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