The Interaction of Hypothalamic Self-Stimulation and Temperature Regulation

Reward produced by intracranial stimulation (ICS) interacts with drives such as hunger[1], thirst[2], and sex[3], indicating that central reward may be similar to the induction of a specific drive and its reduction. Also, ICS is preferred to food by some rats given a choice of ICS or food during 1-h daily tests, and these animals self-starve[4]. The temperature regulation system also fits a drive-interaction paradigm in that rats become hyperthermic during self-stimulation, and rate of obtaining ICS is inversely related to ambient temperature[5,6]. The present study examined whether rats in a cold environment would self-freeze if given a choice between heat and ICS.

Method. Adult male albino rats were trained to work for radiant heat in an ambient temperature of -5 ± 2 °C in a $29 \times 21 \times 23$ cm cage. A Plexiglas lever mounted at one end of the cage activated a pair of infrared heat lamps for a duration of 3 sec at a power dissipation of 150 w per lamp. The lamps were mounted 6 cm outside the cage and focused so that heat covered the lateral surface of the subject from each side. The animals were shaved for all tests including those with ICS. When stable and reliable rates of responding for heat were obtained, 4 monopolar stainless-steel electrodes insulated except for 0.5 mm of beveled tip were implanted. These were directed to various parts of the preoptic area, and anterior and posterior hypothalamus[7]. The reference electrode was a stainless-steel screw affixed to the cranium. Biphasic rectangular pulse pairs of 0.2 msec duration separated by 0.2 msec were programmed at a frequency of 200 pps for a gate duration of 0.3 sec contingent upon a lever response. Base to peak current was determined by measuring the voltage drop across a series resistor with a CRO and appropriate stimulus-isolation transformers. Eleven electrode sites in 8 rats provided stable rates of responding (> 20 responses per min), and these were selected for further study. 2 levers were mounted at opposite ends of the test cage for choice tests; heat reinforcement was programmed on one lever and ICS on the other. A test was terminated after 60 min if the animal had received an average of more than 1 heat reinforcement per min, but was otherwise continued until either continuous responding for heat or ataxia was noted. Rectal temperature (Tre) was measured before and after a test with a thermistor probe inserted 5 cm.

Results and discussion. Baseline rates of heat reinforcement were obtained from the average of three 4-h tests with a 5 day intertest interval, while baseline ICS was obtained from the average of five 30-min tests on consecutive days. These data are given in the Table with the exception of pretest Tre's, which were 37.5 ± 0.5 °C for all tests. Hyperthermia (Tre > 39 °C) during ICS tests was noted for 4 of the 6 subjects with rostral hypothalamic electrodes, but not for subjects with posterior electrodes.

The data for the initial choice tests are presented in the Table, and show that rats with posterior electrodes prefer ICS to heat such that an 84–99% reduction in rate of obtaining heat occurred. The animals typically pressed the ICS lever continuously although rate of responding decreased as time progressed and the subjects became hypothermic. Occasional responses on the heat lever occurred, but these were sporadic. Rigid movements and ataxia were obvious as the rate of ICS approached

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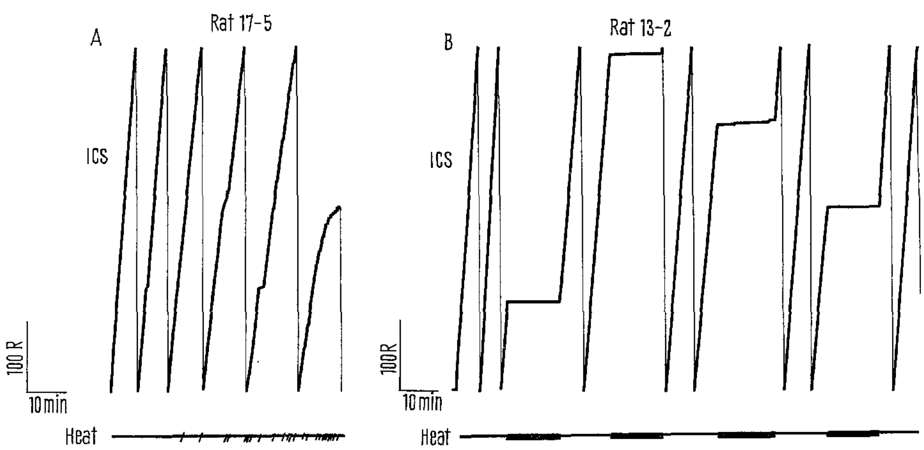
[7] Cresyl-violet stained sections of the brains of the posterior group showed the electrodes were located lateral to the fornix in the medial fore-brain bundle at the level of the mammillary bodies. The rostrocaudal extent of the placements was A3180-A4110 in the atlas of KÖNIG and KLIPPEL[8]. Placements in the rostral group were more diverse, ranging from A5150-A7890. These were located in the medial forebrain bundle at the level of the rostral margin of the ventromedial nuclei (No. 2–4), medial anterior hypothalamus over the posterior portion of the optic chiasma (No. 3–2) nucleus accumbens ventral to the anterior commissure (No. 4–1), ventrolateral to the fornix in the medial forebrain bundle of the anterior hypothalamus (No. 15–5), and dorsolateral to the fornix in the anterior region (Nos. 18–2 and 18–4).



A) Cumulative record showing rate of response for intracranial stimulation (ICS) and the occurrence of heat reinforcements for a rat with a posterior hypothalamic electrode. The subject obtained 2, 768 ICS and 25 heat reinforcements in 64 min. B) Rate of response for ICS during alternating 15 min on-off intervals and the occurrence of heat reinforcements when ICS was not available.

Rates of responding for heat and/or intracranial stimulation (ICS), and post-test rectal temperature

Subject-electrode	Current (μA)	Non-choice baseline				Choice			
		Heat reinforc. per min @-5 °C	Tre (°C)	ICS per min @ 25 °C	Tre (°C)	Rate/min @-5 °C Heat	ICS	Tre (°C)	Test duration (min)
A) Posterior hypothalamic electrodes									
1–5	225	5.1	38.4	108	38.9	0.04	51	21.4	110
3–3	624	4.3	38.5	87	38.0	0.12	37	24.4	52
3–5	624	–	–	65	38.8	0.62	35	25.6	58
13–2	386	6.0	38.0	78	38.6	0.99	27	22.0	112
17–5	295	4.0	38.4	72	38.1	0.38	43	24.3	64
Group mean		4.85	38.32	82	38.36	0.43	38.6	23.54	79
B) Rostral hypothalamic electrodes									
2–4	545	4.9	37.5	57	39.2	1.8	17	34.2	60
3–2	995	4.3	38.5	24	39.4	3.3	21	38.2	60
4–1	995	4.3	38.2	23	39.1	3.0	21	38.2	60
15–5	545	5.4	38.0	67	39.3	1.9	16	36.8	60
18–2	545	5.9	38.4	103	38.2	2.9	61	37.2	60
18–4	545	–	–	63	38.4	4.2	26	37.6	60
Group mean		4.96	38.12	56.8	39.0	2.85	27.0	37.0	60

zero, and feeble attempts to press the heat lever or escape from the cage followed. Average posttest Tre was 23.5 °C, a value that is quite close to the critical temperature for self-stimulation of 22–23 °C[9]. Figure A shows the cumulative record of an ICS-persistent rat. All animals with rostral hypothalamic electrodes alternated between the heat and ICS levers; the reduction in rate of obtaining heat varied between 29–65%. The lowest Tre for an animal in this group was 34.2 °C, while the mean was 37.0 °C.

Subsequent testing showed these results were replicable, and could not be accounted for by a fortuitous current selection or simple perseverative responding on the ICS lever. Animals with rostral electrodes alternated between the heat and ICS levers when current was increased, while subjects with posterior electrodes worked for ICS until current values near threshold were attained and then switched to continuous responding for heat. A compulsive response automatism on the ICS lever by subjects with posterior electrodes was ruled out by making ICS available only 50% of the time; the on-off intervals were 10, 15, or 20 min. The output of the stimulator was disconnected at the end of an ICS interval, while 2 free stimulations were given to signal the availability of ICS at the end of a time-out period. Heat was available at all times. The subjects worked for ICS when it was available, but promptly began to press for heat when it was not. Figure B shows an example of alternation obtained in this manner.

Briese et al.[5,6] have suggested an overlap of temperature and reward systems based on a dual-center model of the thermoregulatory system proposed by Benzinger[10]. Persistent responding for posterior ICS in the cold is consistent with this view, but hyperthermia with rostral ICS is not. The difficulties involved in a consistent application of the Benzinger model to ICS data could mean either that the model is inadequate or that the drive-interaction paradigm itself is inadequate[11].

Résumé, Placés dans un environnement froid, les rats qui avaient des électrodes implantés dans l'hypothalamus postérieur, préféraient la stimulation intracrannienne à un réchauffement de l'environnement; de ce fait, ils devenaient hypothermiques. Les rats qui avaient des électrodes implantés dans l'hypothalamus antérieur actionnaient alternativement les leviers de chauffage et ceux du courant électrique; ils évitaient ainsi de devenir hypothermiques.

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[11] Supported by grant No. MH-12414 from USPHS.

Vagus Pneumonia as Membrane Phospholipase Activation

Lissák et al.[1] pointed to a sympathetic predominance after vagotomy. We tried to approach the direct site of sympathetic neural control in the lipid metabolism of cytosomal fraction, obtained from the rabbit lungs after vagotomy.

We conducted the experiments on rabbits weighing from 1.6–2.4 kg. To avoid the aspiration the rabbits were tracheotomized after the bilateral cervical vagotomy. A similar procedure was carried out on sham operated rabbits without vagotomy. 5 h after vagotomy rabbits were exsanguinated and the lungs removed immediately. Cytosome fraction of lung was obtained by means of centrifuging with 20,000 *g*, according to procedure of Reiss[2] after preparing homogenates in 0.3 *M* sucrose