Psychol. Belg.
1980, xx-2, 179-184.

Université de Louvain
Laboratoire de Neurophysiologie

EFFECTS OF VARYING ENVIRONMENTAL CONDITIONS UPON SELF-STIMULATION BEHAVIOR OF THE RAT

PHILIPPE DE WITTE

Rats, implanted with chronic electrodes at the postero-lateral part of the hypothalamus, were allowed to self-regulate the train duration of electrical rewarding brain stimulation in two different surroundings, i.e. home cage and strange cage. The total time of self-stimulation, the number of bar pressings, as well as the mean duration of bar pressing were automatically recorded. Results show that the total time of self-stimulation and the number of bar pressings increase in the strange cage while the mean duration of bar pressing decreases. It is assumed that the environment of a strange cage offers fewer positive properties than the environment of the home cage because self-stimulation behavior is higher in the strange cage.

INTRODUCTION

Since Brady and Conrad's (1960) report on the rewarding effect of electrical stimulation of the septal area and the inability to elicit conditioned emotional behavior during such septal stimulation, the effect of rewarding stimulation upon the emotional state has been studied in two different ways.

The first approach related self-stimulation to the emotional state it induced. According to this kind of relationship, rewarding electrical stimulation of the brain should have a masking property upon "conditioned fear behavior" (Brady, 1960) and attenuate aversive reactions to peripheral shock (Cox & Valenstein, 1965; De Witte, 1979).

The second approach correlates the endocrinological aspects of the emotional state with self-stimulatory behavior. Discussion continues concerning the inhibitory or excitatory effect of rewarding brain stimulation upon the pituitary-adrenocortical axis (reviewed by Sadowsky, 1975). It seems that the observed divergences result from differences in species used, the anatomical locus of electrical stimulation, the choice of variable measured (hormone in blood or in adrenal tissue), the way in which the reward is given (by the experimenter or by the animal himself), and finally the stimulus parameters and the experimental situation.

The author is indebted to professor M. Meulders for constructive criticism. We are pleased to thank Mrs. Fr. Huybrechts-Ameels, Mrs. Fr. Langhendries-Vrins, Mr. Ch. Hendrick, Mr. J. Schouppe and Mr. Ch. Stoquart for their technical assistance.

It is well known that a particular environment can elicit an emotional state, such as anxiety, aggression or fear. The purpose of this paper is to study possible positive or negative potentiation of the environment upon self-stimulation behavior. One might suppose, for instance, that modification of the environment could modulate the intensity of self-stimulation behavior. In order to test this hypothesis, two different environments were chosen : a home cage and a strange cage. In contrast to home cage conditions, the environment of a strange cage is known to induce affective arousal in the rat by increasing locomotor activity and exploratory behavior, as well as increasing defecation (Archer, 1973).

METHODS

SUBJECTS, TRAINING, AND HISTOLOGY

Subjects were male albino rats of the Wistar strain, each weighing 300 g at the time of operation. Each rat was implanted with two monopolar nickelchrome electrodes (0,25 mm diameter), insulated except for the cross section of the tip. The region aimed at was the postero-lateral hypothalamus. The indifferent electrode was placed 1 mm anterior to the bregma. The electrodes were implanted bilaterally and stereotaxically according to the following coordinates: A 3,5 mm posterior to bregma; L 1,2 mm; H 8,3 mm below the skull surface.

After the operation, animals were allowed to recover for one week before training for self-stimulation began. Pressing a reinforcing lever produced a 0,5 second train of negative rectangular pulses of 0,1 msec duration delivered at a frequency of 100 Hz. Current threshold for self-stimulation behavior ranged from 70-150 μA and was monitored by means of an oscilloscope. Rats were given daily training sessions until the bar pressing rate became steady. Rats which did not exhibit self-stimulation behavior were eliminated from the study.

Following the termination of the experiment, the subjects were sacrified. The brains were removed from the skull and put in formalin solution for ten days. The brains were then frozen, sectioned at 100 μ, and stained with cresyl-violet.

PROCEDURE

Animals were allowed to self-regulate rewarding brain stimulation in wooden enclosures 75 cm long, 60 cm wide and 55 cm high. A lever (10 cm × 4 cm × 0,2 cm) was placed 2 cm above the floor and 3 cm from a corner. The lighting of the experimental rooms was alternated : 12 h light – 12 h dark, to obtain a diurnal activity cycle. The temperature of the rooms was maintained at 23°C. All the animals had water and laboratory pellets to satiety. The self-regulation behavior of the train duration of rewarding brain stimulus was observed in the home cage and in the strange cage. In the home cage situation the rat was

habituated to the cage for two weeks before observation was begun. In the strange cage self-stimulation behavior was observed in the home cage of another male rat.

Six electrical combinations of increasingly rewarding intensity were: 0,1 msec pulse width delivered at the frequency of 100, 200 and 300 Hz, and 0,2 msec at 100, 200 and 300 Hz. Each electrical combination was used as a reward for a period of ten minutes, and this procedure was repeated three times. After each period of 10 minutes, the total time the animal had self-stimulated himself (T), the number of bar pressings (N), as well as the mean duration of bar pressing (M = T/N), were automatically calculated. Figure 1 shows the obtained histograms of the duration of bar pressing for the sample, i.e. 3 times 10 min for each of the 6 rats (180 min recordings in total for each electrical combination in each environment).

RESULTS

The obtained values of N and T are presented in figure 1. The time histograms show a first peak lasting $^{1}/_{10}$ sec, probably representing motor readjustment behavior during self-stimulation. This figure shows clear differences in the values of N and T according to the electrical combination presented to the rat. From the assumption that the greater the total time of self-stimulation, the more rewarding is the stimulus, it follows that an increase in the physical value of the brain stimulus corresponds with an increase of the rewarding value in the home as well as in the strange cage. Nevertheless, it seems that this increase depends upon the environment. The amount of time that the animals self-stimulated during the experiment (i.e. seconds per 10.800 sec for each electrical combination) shows a dramatic increase while in the strange cage environment. Furthermore, for the last electrical combination (0,2-300), the animals spent $^{2}/_{3}$ of their time self-stimulating in a strange cage versus one half of their time while in the home cage. Wilcoxon's test accepts differences in the total time the animal had self-stimulated himself (T) between home and strange cage, except during the regulation of the parameter 0,1 msec pulse width delivered at 100 Hz. Thus, in a strange cage environment, rats spend the majority of their time self-stimulating. Exploratory and locomotory behavior are rarely seen, the animal being riveted to his pedal. All his activity is focused upon the obtainment of the rewarding brain stimulus. His self-stimulation behavior is quite different in his home cage, where more brief bar pressing takes place.

Furthermore, the behavioral manifestations that ordinarily accompany the strange cage situation – exploratory and grooming behaviors – do not appear. It would seem likely then that self-stimulation behavior prevents the behavioral manifestations linked with a strange environment.

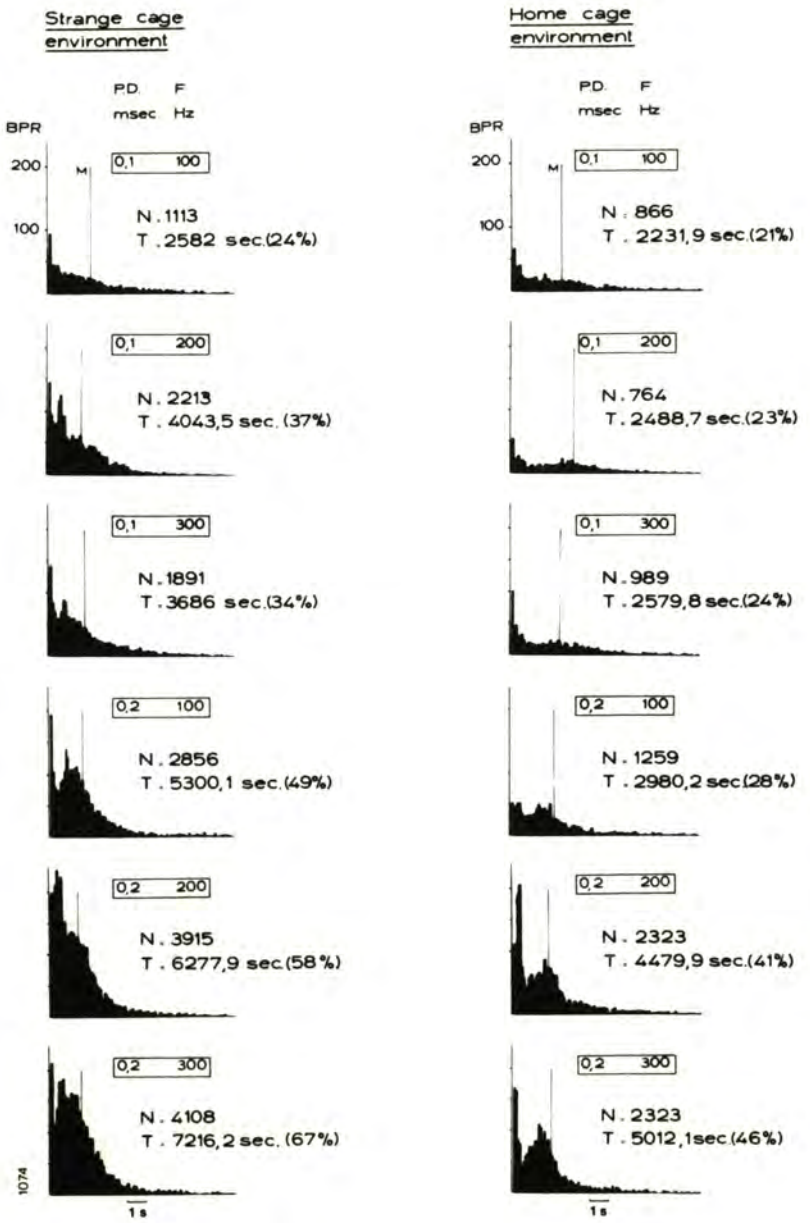

FIG. 1. REPRESENTATION OF THE TIME HISTOGRAMS OF BAR PRESSING. On the ordinate is presented the cumulative frequency of bar pressing (BPR), plotted against the time of each bar pressing on the abscissa. Six brain electrical combinations varying the pulse duration (PD) and the frequency of pulses (F) were presented into two environments, strange and home cage. The value of the number of bar pressings (N), the total time spent in self-stimulation (T) as well as the mean value of a bar pressing (M) are also presented. In parentheses, near the value of T, is presented the percentage of time out of the total time (10.800 sec) spent in the environment during which the animals had effectively self-stimulated

Since von Holst and von Sain-Paul (1963) indicated that organized behavior elicited by limbic stimulation could be modulated by environmental factors, it has become apparent that self-stimulation behavior may also be environment-dependent (see also De Witte, 1978, Mendelson, 1972 and Valenstein, 1970). Moreover, as Mendelson pointed out, the emotional tone of the brain stimulation is dependent upon the environment. This observation is confirmed by experiments where the implantation of rewarding electrodes into human brain (Sem-Jacobsen & Styri, 1972) indicate that the mood of the experimenter highly influences the valence of the brain stimulation. These results point out that environmental conditions modulate the reward elicited by brain stimulation.

By testing the effects of varying environmental condition upon self-stimulation behavior, our experiment shows that the external conditions can highly potentiate self-stimulation. In other words, it is assumed that an increase in self-stimulation behavior, with all other conditions except the environment being constant, could be due to the negative influence of the strange cage situation (Archer, 1973). Our assumption is that animals increase their self-stimulation to compensate the negative effect elicited by strange cage environment. In the same way, in the home cage condition, the self-stimulation behavior decreases because the situation offers sufficient positive properties inducing a sufficient level of rewarding effects. Furthermore, as figure 1 shows, the increase of the time spent in self-stimulation is also dependent on the intracranial reward elicited by the electrical parameters. The same progression is seen in the home as well as in the strange cage environment. This observation is consistent with our knowledge of the affective integration of the brain. Following this assumption, it seems profitable to study the correlation of the anatomical site of the electrode, the animal's behavior and the experimental conditions under which the behavior is observed, in order to better understand the reinforcing properties of positive brain stimulation.

REFERENCES

ARCHER, J. Tests for emotionality in rats and mice: A review. *Animal Behaviour*, 1973, *21*, 105-135.

BRADY, J.V. *Electrical studies on the unanaesthetized brain*. New York: Huber, 1960.

BRADY, J.V., & CONRAD, D.G. Some effects of limbic systems self-stimulation upon conditioned emotional behavior. *Journal of Comparative and Physiological Psychology*, 1960, *53*, 128-137.

COX, V.C., & VALENSTEIN, E.S. Attenuation of aversive properties of peripheral shock by hypothalamic stimulation. *Science*, 1965, *149*, 323-325.

DE WITTE, PH. Reinforcing stimulation of the postero-lateral hypothalamus and mating behavior in the rat. *Arch. int. Physiol. Bioch.*, 1978, *86*, 985-995.

DE WITTE, PH. Compensatory effects of hypothalamic rewarding stimulation during concomitant painful footshock. *Physiology & Behavior*, 1979.

MENDELSON, J. Ecological modulation of brain stimulation effects. *International Journal of Psychobiology*, 1972, *2*, 285-304.

SADOWSKI, B. Physiological correlates of self-stimulation. In A. WAUQUIER & E.T. ROLLS (Eds.), *Brain-stimulation reward*. Amsterdam : North-Holland, 1975.

SEM-JACOBSEN, C.W., & STYRI, O.B. Electrical stimulation of the human brain : Pitfalls and results. G.G. SOMJEN (Ed.), *Neurophysiology studied in man*. Amsterdam : Excerpta Medica, 1972.

VALENSTEIN, E.S. Reexamination of the role of the hypothalamus in motivation. *Psychological Review*, 1970, *77*, 16-31.

VON HOLST, E., VON SAINT-PAUL, V. On the functional organization of drives. *Animal Behaviour*, 1963, *11*, 1-20.

Laboratoire de Neurophysiologie
U.C.L. – 54.49
Avenue Hippocrate 54
1200 Bruxelles

Received January 1979