Train Length Perception During Self-Stimulation Behaviour

The study of perceptual aspects in intracranial self-stimulation behaviour has been performed by using a conditioning technique which utilizes the rewarding electrical stimulation of the brain (REBS) as conditioned stimuli[1–6]. In this work, an attempt is made to study some perceptual aspects of REBS by employing a different technique. More specifically, we try to determine if animals perceive train length during self-stimulation behaviour. It is expected that if animals actually perceive train length, bar pressing will depend on the train length.

In order to test the hypothesis we have reasoned as follows: if animals perceive the onset and offset of electrical stimulus, then with an appropriate training animals must always press the bar to start the stimulation; and they will press the bar again only when the stimulation is turned off. In fact, animals will learn that if they press the bar when the stimulus is turned on, this bar press has no reward effect; and consequently they will eliminate this response. If bar pressing can be recorded in such a way that it is possible to know when animals press the bar and when the stimulus starts and stops, the preceding proposition can be tested.

Method. 50 male albinos rats (Witstart) were implanted with a monopolar electrode (nickel chrome, 0.25 mm) in the lateral posterior hypothalamus, according to a technique previously described[7]. A week after the operation, animals were trained for self-stimulation behaviour in a modified Skinner box ($30 \times 30 \times 12.5$ cm) to press a bar (10×3 cm) to start a stimulator delivering negative monophasic rectangular waves; 0.5 sec train length, 100 Hz and 0.1 millisec per pulse. The intensities varied between 150 and 300 μA according to the threshold of each animal. The mean intensity for the sample was 230 μA. Of the 50 implanted animals, 10 exhibited a self-stimulation behaviour; these 10 rats were allowed to self-stimulate twice daily, for periods of 30 min during 6 weeks. At these sessions, 38 different parameters of stimulation previously studied[7] were presented to the animals for self-stimulation. These parameters of stimulation varied by their frequencies, pulse duration or train length. This overtraining was realized to permit animals best to appreciate the reward strength of this stimulation and secondly to obtain well stabilized performances. When this overtraining was finished, the animals started the experiments.

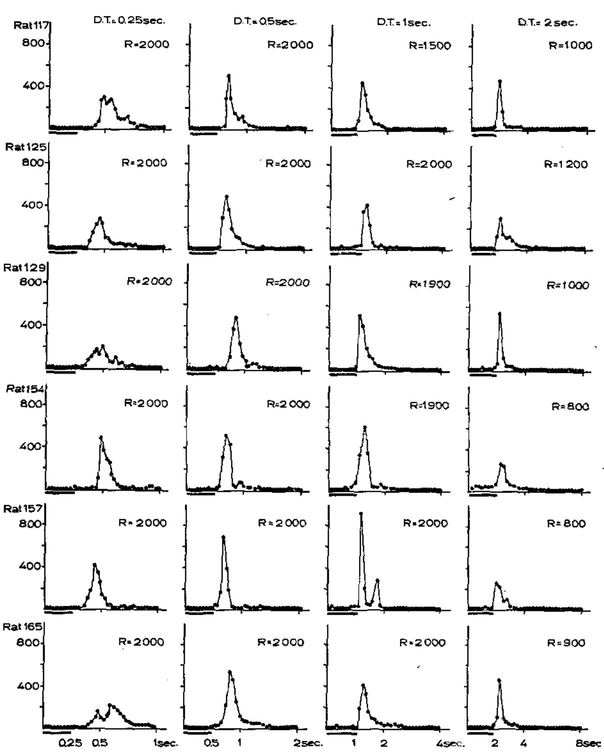

Fig. 1. Interval histogram of bar-pressing from a sample of 6 rats, for train length of 0.25, 0.5, 1 or 2 sec (left to right column) for a total number of responses represented by R. Points represent frequencies (ordinate) at which a given interval between successive responses occurs. The dark line (below abscissa) represents the stimulus duration. Notice how the animal responses are synchronized with the stimulus duration.

Each time the animal presses the bar, 2 stimulators are started simultaneously. One stimulator delivers to the rats a stimulation of 0.25, 0.5, 1 or 2 sec train length, 300 Hz, 0.2 msec per pulse with intensities varying between 150–300 μA. The other stimulator sends a pulse to a Data Retrieval Computer, Nuclear Chicago, programmed to analyze the interval between responses. In this form, an 'interval histogram' is obtained. If the animal presses the bar when the intracranial stimulation is turned on, this bar pressing does not start the first stimulator, but the second stimulator sends a pulse to the Data Retrieval Computer. The time analysis of the interval histogram program corresponds to 4 times the stimulus duration. By this procedure it is possible to see if the time interval between responses is inferior, superior or identical to the stimulus duration. If having examined a series of intervals between successive responses, we observe that the duration of such intervals is identical or sligthly longer than the stimulus duration, we conclude that animal has pressed the bar when the intracranial stimulation is turned off; and it is possible only if animal perceives the offset of the stimulation.

A sample of 6 rats performed this experiment, working 4 times for each train length, realizing a total of 12,000 responses for train length of 0.25 and 0.5 sec; 11,300 responses for the train length of 1 sec; and 5,700 responses for the train length of 2 sec. These 4 separate tests are used in order to avoid a fatigue effect and to obtain more reliable data.

Results. We observe that the time spacing 2 successive responses is very constant for a given train length; and the interval between this successive response is equally or slightly greater than 0.25, 0.5, 1 or 2 sec for train length of identical values. So, as we have previously pointed out, this means that animals generally press the bar at the moment when stimulus stops. And in virtue of our hypothesis, this synchronization of bar pressing and train length imply that animals perceive the train duration (Figure 1).

Another fact to be observed is that, for a train length of 0.25 sec, the majority of the responses occur within

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intervals inferior to 0.5 sec. This means that animals press the bar at 2 per sec for a train length of 0.25 sec. But, when stimulus durations are 0.5, 1 or 2 sec, interval responses are superior to 0.5, 1 and 2 sec respectively. In other words, animals press the bar at 2 times per sec, once per sec or once every 2 sec. However these rates are very inferior to a rate of 2 per sec which we have seen animals can perform. Consequently bar pressing rates of 0.5, 1 or 2 per sec are not due neither to fatigue, or to the fact that animals rise to a maximum performance level, but to the fact that animals control their performance in function of train length.

To obtain this synchronization between performance and train length, it is necessary to employ stimulation parameters with a high reward level. Based upon previous studies[7,8] in which the reward strength of several stimulations are evaluated by different behavioral criteria, we have chosen a less rewarding stimulation and in this eventuality, this synchronization between bar pressing and train length cannot be observed (Figure 2). In addition, very well trained animals are necessary and these animals must work in a very quiet environment. Indeed, we observed that if an unexpected noise occurs, animals desynchronize their performances (Figure 2).

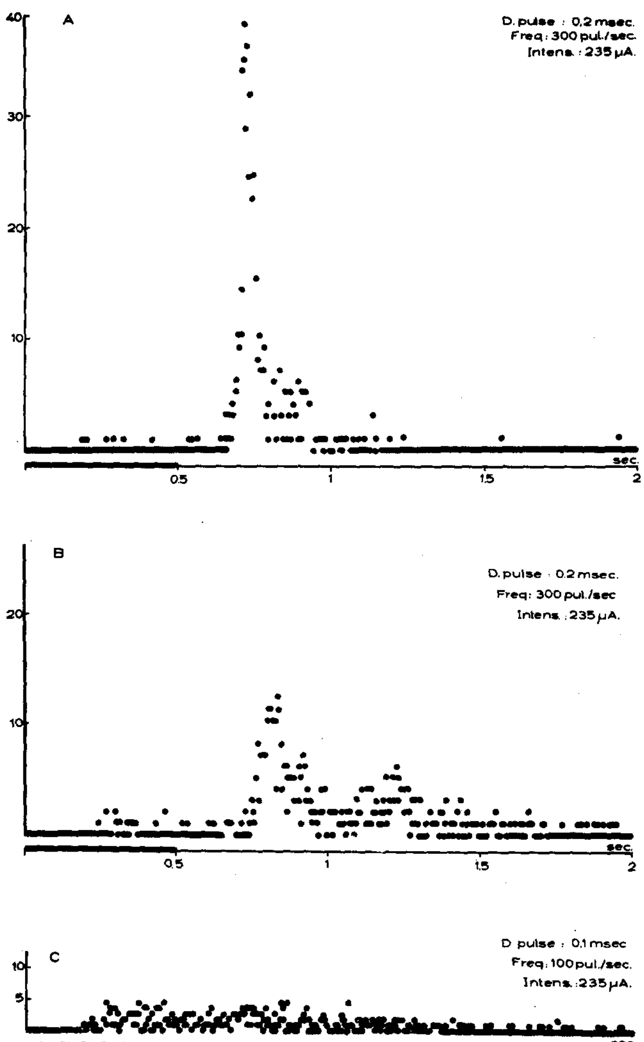

Fig. 2. The interval histogram (as presented in Figure 1) describes the performance of an animal working in a quiet environment (A); the performance in a non-quiet environment or when an unexpected noise is produced (B); and when an animal self-stimulates for a less rewarding stimulation (C). Notice how the performance is synchronized with the stimulus duration in case A. It is not so in cases B and C.

Conclusion. This experiment shows that when animals self-stimulate, they do not press the bar in a haphazard manner. On the contrary, animals perceive when the stimulus is turned on and off. This perception permits animals with sufficient training and adequate parameters of stimulation to synchronize their performances depending on train length. But this procedure does not answer the following question: why, for less rewarding stimulation, do animals not bar-press depending on train length?

An explanation of this fact may be the following one: if we assume that a stimulation eliciting a synchronized performance presents a strong reward effect, we can expect that animals, working by reward, will try to self-stimulate all the time in order to receive a maximum reward. The most expedient manner to carry on this process is to synchronize the bar pressing with the end of the train. Consequently animals will press the bar at the end of the stimulation. On the contrary, when the stimulation parameter is not so strong, reward strength will be inferior and animals will self-stimulate too, but they do not try to reach a maximum performance, in order to obtain a maximum reward. Consequently animals will not press the bar each time the stimulus is finished; this may explain why animals under this stimulation parameter work haphazardly.

A last problem we can investigate with these data is the following one. If we suppose that animals work for the reward effect, it is possible that this effect will be present only as long as the stimulus is turned on, or persist when the stimulus is turned off. If we assume that animals work for the reward effect, we can expect that they will press the bar in order to obtain a new reward at the moment when the reward is extinguished. Since we observe that animals press the bar at the moment the stimulus is turned off, or some msec later, we tend to conclude that the reward effect elicited by this stimulation persists as long as the stimulation is turned on or some msec later.

Résumé. Pendant le comportement d'autostimulation électrique intracérébrale, l'animal n'appuie sur la pédale qu'à la fin du train de stimulation. Un tel comportement est interprété en émettant l'hypothèse que l'animal perçoit la durée de la stimulation. Mais un tel comportement dépend d'une part de l'intensité de l'effet de récompense et d'autre part de l'environnement. En effet si l'intensité de la récompense est moins importante ou si des stimulations sonores inattendues surviennent, les Rats ne parviennent plus à réaliser ce comportement.

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