Defence, Attack, and Flight Elicited by Electrical Stimulation of the Hypothalamus of the Cat

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Summary. 1. Affective behaviour patterns produced by electrical stimulation of the hypothalamus were studied in unanaesthetized, freely-moving cats. Bipolar stimulation with coaxial electrodes and small cathode was used to elicit defence, attack or flight. The development of these responses was studied by varying stimulation strength. In some experiments a stuffed animal was introduced in order to study the reactions of the cat to changes in the environment during stimulation.

2. The following responses were evoked at threshold intensity: (i) growling reaction; (ii) hissing reaction; (iii) two types of flight — type a preceded by hastily looking to and fro as if in search of an exit, type b preceded by inspection of surroundings, in most cases associated with sniffing.

3. Increasing stimulation 1.5 times threshold often yielded combined patterns. At points yielding the growling reaction a defence response in which growls alternated with hisses was obtained. The points yielding flight type a sometimes yielded hissing followed by flight. Increasing stimulation at hissing points yielded either a defence reaction or the combined effect hissing-flight.

4. The growling reactions were obtained from the tuber region. The hissing responses were obtained from points above the tuber. The flight reactions, type a, were produced from the intermediate zone extending from the level of the preoptic area to the mamillary bodies and type b from the caudo-lateral hypothalamus.

5. The reactions of the cats to a dummy during stimulation varied depending on the type of response which had been evoked in the absence of the dummy. The defence reaction was converted into threatening and striking of the dummy, the combined effects into threatening, striking or biting, culminating in sudden flight. The dummy was ignored during stimulation of points yielding flight type a, but examined by sniffing during stimulation of points yielding flight type b.

Key Words: Emotional behaviour — Hypothalamus — Electrical stimulation — Cat

Introduction

Integrated defence or flight reactions can be elicited by stimulating the hypothalamus in unanaesthetized, freely-moving cats (HESS and BRÜGGER 1943; HUNSPERGER 1956; NAKAO 1958; ABRAHAMS, HILTON and ZBROŽYNA 1960; YASUKOCHI 1960; ROMANIUK 1965). Each of these reactions is represented in different areas. For example HESS and BRÜGGER (1943) obtained the defence reaction (characterized by marked dilatation of the pupils, hissing sometimes
alternating with growling, lowering of the head, flattening of the ears and pilo-erection on back and tail) from the “perifornical region”. Hunsperger (1956) has shown that this defence zone lies embedded in a wider field from which the flight reaction is obtained. This reaction is characterized by only moderate dilatation of the pupils, hasty looking around as if in search of an exit, and finally a dash to escape. It was further found that increasing the intensity of the stimulation in the defence zone evokes defence reactions culminating either in rushing forward as if to attack or in sudden flight, and that increasing the intensity of stimulation in the flight field may produce a combined pattern of hissing followed by flight.

If a stick or hand is extended towards the cat during stimulation of the defence zone (Hunsperger 1956; Nakao 1958), or a fellow cat (Delgado 1955) or live rat (Wasman and Flynn 1962; Roberts and Kies 1964) is placed on the table, the stimulated animal strikes the object presented with unsheathed claws. If the animal is hindered in its flight during stimulation of the flight zone, the reaction may change from flight to defence accompanied by vigorous hissing and often followed by flight.

Thus, by stimulating a single site in the hypothalamus it is possible to elicit a gradually evolving constellation of behaviour patterns which appear to enable the animal to protect himself from an enemy. The purpose of the study reported here was, by using coaxial electrodes and a small cathode tip, to attempt a more precise localization of the areas which subserve each of the elements of the behaviour pattern. The effects of varying the intensity of the stimulation and of presenting various sensory cues available to the animal were also studied.

Methods

The Hess procedure for stimulating deeply lying brain structures in unanaesthetized freely-moving animals was used (Hess 1932, 1957). The experiments were carried out on 36 adult cats of both sexes, body weight 2.2–3.8 kg. The stimulation electrodes were coaxial, 0.4 mm in diameter and constructed of stainless steel (Fig. 1). The cathode was the 0.3 mm bared tip of the core 0.15 in diameter which emerged 1.0 mm from the tube; the anode was the 0.5 mm bared end of the tube. These electrodes were mounted in pairs 3 mm apart in a frame, and lowered — one set on each side — 23–26 mm into the brain in several sagittal planes from 0.5–3.5 mm from the midline, the anterior electrode 1.5 mm rostral to, and up to 4.5 mm caudal to the coronal suture. All surgery was carried out with the cats anaesthetized with N₂O and local areas of scalp infiltrated with procaine. The animals showed no signs of discomfort during the experiments. They were in a relaxed posture at the onset of stimulation and were free to jump off. Electrical stimulation was carried out by means of a transistorized Wyss stimulator (1959, 1965) delivering impulses with delayed rise and fall. The impulses had a rising time of 5 msec and a total duration of 15 msec. They were delivered to the electrode over a high frequency isolation unit (J. Monti, Geneva) and a condenser of 16 μF put in series with the lead to the cathode. Frequency of stimulation was 16/sec, intensities ranged between 1 and 5 V. Stimulation lasted 1 min or until the cat jumped from the table, which pulled out the microcontacts inserted into both leads. There was a minimum interval of 4 min between stimulations.

Fig. 1. Coaxial electrode. Active surface of tip serving as cathode = 0.15 mm² approx., active surface of base of the tube serving as anode = 0.63 mm². Calibration: 1 mm