HYPNOGENIC ACTION OF A MODULATED ELECTROMAGNETIC FIELD

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The dynamics of behavioral and electroencephalographic changes in rats were studied during prolonged exposure to a modulated electromagnetic field (frequency 40 MHz, frequency of modulation 50 Hz, intensity 100-120 V/m). Exposure to a modulated electromagnetic field was found to cause the appearance of phasic disturbances in conditioned food and defensive reflexes or even the development of a cataleptic state. These behavioral disturbances are due to changes in normal cortico-subcortical relations.

KEY WORDS: modulated magnetic field; hypnogenic action; epileptiform activity; catalepsy.

During a study of the action of modulated electromagnetic fields (MEMF) on animal behavior [1-3] the writers observed that following exposure of a certain duration or to a field of a certain intensity, a state resembling catalepsy develops in some animals. Other workers [4-7], who exposed animals to various electromagnetic fields for long periods of time, also observed changes in behavioral responses largely resembling the hypnotic phases described in Pavlov's laboratory. The development of states of the catalepsy and narcolepsy type in man with particularly severe lesions caused by exposure to electromagnetic fields has also been reported by clinicians [8].

To study the hypnogenic action of MEMF the dynamics of changes in the behavioral responses of rats was investigated and compared with changes in electrical activity of the cortex and subcortical brain structures following exposure to MEMF for different periods of time.

EXPERIMENTAL METHOD

Experiments were carried out on 76 noninbred albino rats of both sexes. Conditioned food and defensive reflexes to the same photic stimulus, but associated with different colors of the replaceable back wall of the chamber, were first produced in the animals in a special chamber. The nature of the conditioned reflex was as follows: If the back wall of the chamber was white the animals visited the feeding bowl located by the left side wall of the chamber. If the back wall of the chamber was black, in response to the conditioned stimulus the animals showed a defensive reflex and hid in the right side of the chamber, for in that case an electric current was applied to the floor of the left side of the chamber in front of the feeding bowl. Electrical activity of the cortex and various subcortical formations of the brain was recorded in the rats. The conditioned reflexes were studied in response to the action of an MEMF (frequency 40 MHz, frequency of modulation 50 Hz, depth of modulation 80-100%, intensity 100-120 V/m, duration of exposure 2 min to 2.5 h), produced by a generator in the chamber with the aid of condenser plates fixed along its walls.

In a series of experiments groups of rats consisting of six to eight animals were exposed to the action of such an MEMF.

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TABLE 1. Selective Phasic Disturbances of Established Conditioned-Reflex Goal-Directed Defensive and Food Behavior in Rats after Exposure for Various Periods to Modulated Electromagnetic Field

Phase	Duration of exposure to MEMF	Defensive behavior	Food behavior
1st	5-20 min	Selective disturbance of conditioned defensive reflexes; repeated movement in response to conditioned stimulus in direction of feeding bowl despite painful stimulation	Increase in fluctuations of reaction time from beginning of conditioned stimulation to reinforcement
2nd	20-45 min	Movements in direction of feeding bowl in response to conditioned stimuli, despite painful stimulation	Increase in reaction time from beginning of conditioned stimulus to reinforcement; appearance of defensive reflexes in "food" situation in response to conditioned stimuli and motor responses toward feeding bowl but not culminating in the taking of food
3rd	45-60 min	No response to triggering conditioned stimulus	No response to triggering conditioned stimulus
4th	1.5-2.5 h	Deep depression of general motor activity; animals remained in unnatural postures in which they were placed (waxy flexibility); absence of behavioral and EEG responses to direct nociceptive stimulation	Absence of chewing and swallowing of food when placed in mouth

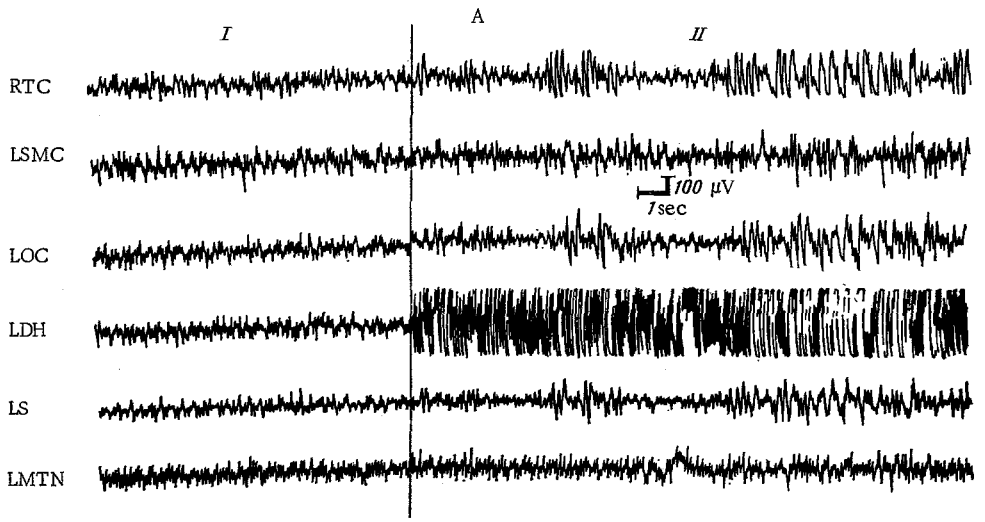

Fig. 1. Changes in electrical activity of rat brain at different stages of prolonged exposure to MEMF: A) 1st, B) 2nd, C) 3rd, D) 4th phases (explanation in text). I) Spontaneous electrical activity; II) electrical activity after exposure to MEMF for 15 min. RTC) Right temporal cortex; LSMC) left sensomotor cortex; LOC) left occipital cortex; LDH) left dorsal hippocampus; LS) left septum; LMTN) left middle thalamic nucleus. [Figure continues on next page.]

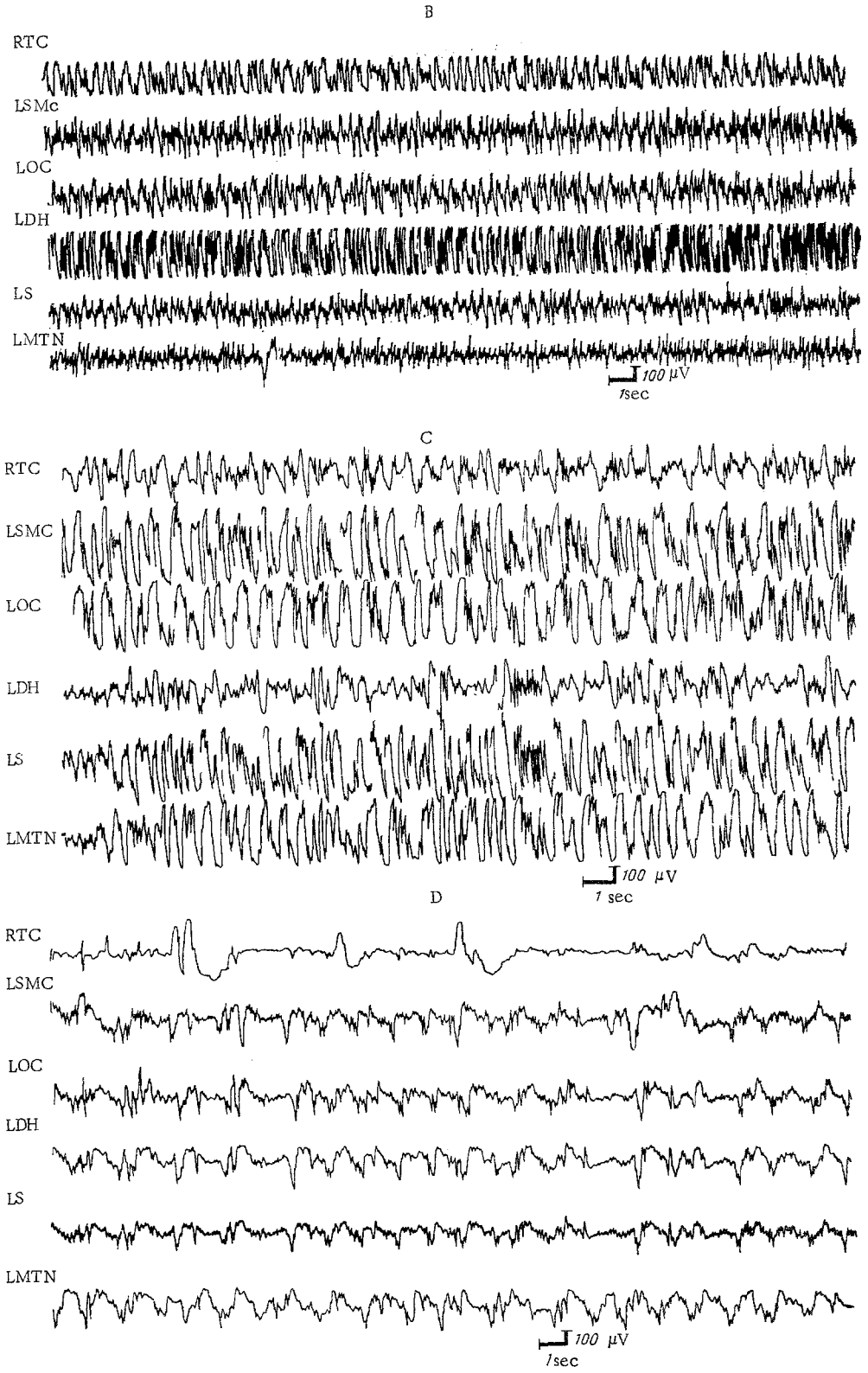

Fig. 1. (Continued)

Fig. 2. Rats in state of catalepsy.

EXPERIMENTAL RESULTS

The experiments showed that during prolonged exposure to the MEMF the animals developed four distinct phases of disturbance of conditioned food and defensive reflexes (Table 1). The first phase was observed in 54% of animals. It was characterized by the appearance of local epileptiform activity in the dorsal hippocampus (Fig. 1A). The second phase was observed in 75% of experimental animals. In this phase epileptiform activity was recorded in the hippocampus, hypothalamus, septum, and amygdala, and also in the temporal and occipital regions of the cortex (Fig. 1B). The third phase was observed in 86% of the animals studied. In this phase the epileptiform activity extended to all brain structures investigated (Fig. 1C). The fourth phase (Fig. 1D) was characterized by the appearance of generalized slow (1-2 Hz) pointed waves with an amplitude of 150-200 μV in the parts of the brain studied or by depression of the EEG. This stage was observed in 35% of animals. True catalepsy with signs of "waxy flexibility" developed in 5% of rats.

Changes similar to those described above were observed in the behavior of a group of rats consisting of six to eight animals exposed to an MEMF and whose functional state was about the same during free behavior in the chamber after feeding. Five such groups were studied. During the first few minutes of action of the MEMF the general motor activity of the animals increased. By the end of the first hour motor activity was inhibited, but it increased steadily during exposure to MEMF. After the first hour of exposure the rats became gradually "tame," for they did not respond to sudden sounds, to stroking, and so on. After exposure for 1.5-2 h the motor activity of practically all the animals was profoundly depressed. The rats no longer responded not only to sensory, but also to biological stimuli, such as placing a rabbit or even a cat in the experimental chamber. In these experiments, moreover, 5% of the animals developed a cataleptic state (Fig. 2).

The experiments thus showed that during prolonged exposure to an MEMF (50 Hz) phasic changes in behavioral responses due to disturbance of normal cortico-subcortical relations are observed in animals.

The phasic changes discovered in behavior and in brain electrical activity of rats, manifested during exposure to an MEMF are largely reminiscent of the hypnotic phases described in Pavlov's laboratory. The first phase, for instance, can be regarded as "paradoxical," the second as "ultraparadoxical," the third as "inhibitory," and the fourth as "cataleptic." Hence there is reason to suppose that the MEMF may have a hypnogenic action.

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