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CORRELATIONS BETWEEN THE FUNCTIONAL STATE OF THE CNS AND THYROID ACTIVITY IN CHRONIC EMOTIONAL STRESS

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Cortical and subcortical electrical activity was recorded during chronic emotional stress in cats and the state of thyroid function determined. Correlation was found between the functional state of the CNS and the level of thyroxine secretion. The trigger role of the posterior hypothalamic nucleus in the genesis of hypersynchronized activity in stress was demonstrated.

KEY WORDS: thyroid gland; stress; central nervous system.

The study of correlation between the functional state of the CNS and of the glands of internal secretion has not been undertaken during chronic emotional stress. There have been only a few isolated investigations [2, 4, 5] under acute experimental conditions. However, we know [3, 7] that it is the duration and repetition of negative emotions that play an important role in the conversion of protective reactions into a phase of overstrain, the starting point of formation of pathological syndromes. They become a background facilitating the development of certain neurogenic diseases such as essential hypertension, myocardial infarction, etc. Several workers have shown by neurophysiological analysis of emotional stress of varied genesis [6, 8-10] that the electrical activity of the brain during emotional stress reflects considerable phase shifts in relations between the cortex and deep brain structures. Analysis of the results of these investigations shows that although the authors cited noted that deep brain structures are activated before the cortex, the question of which deep brain formations perform the function of triggering mechanism, or in other words, where electrical responses to stress are formed initially and what is the time course of consecutive activation of the various hypothalamic nuclei, reticular formation, and structures of the limbic system, still remains unanswered. Yet another important question has not yet been studied: What changes take place in brain electrical activity in animals exposed repeatedly to stress for several days?

The object of the present investigation was to study correletion between the functional state of the CNS and peripheral glands of internal secretion with particular reference to activity under conditions of chronic emotional stress.

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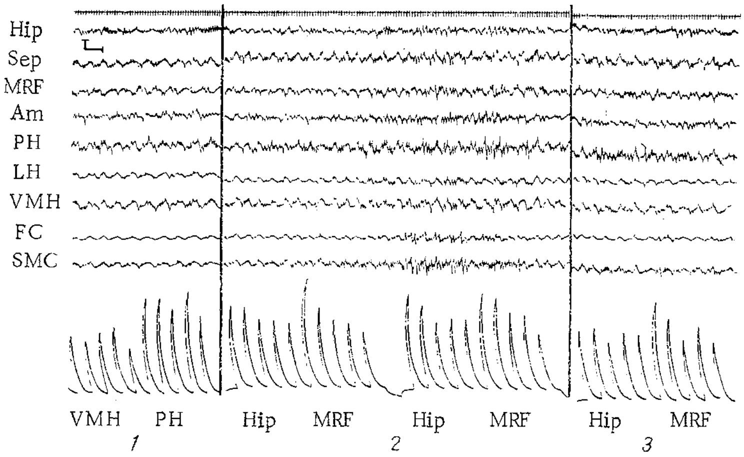

Fig. 1. Time course of EEG changes of cat during immobilization with electrodermal stimulation (1st day). 1) Beginning of immobilization, 2) 10 min, 3) 30 min after EDS. Hip) Hippocampus, Sep) septum, MRF) mesencephalic reticular formation, Am) amygdala, PH) posterior hypothalamus, LH) lateral hypothalmus, VMH) ventromedial hypothalamic nucleus, FC) frontal cortex, SMC) sensomotor cortex.

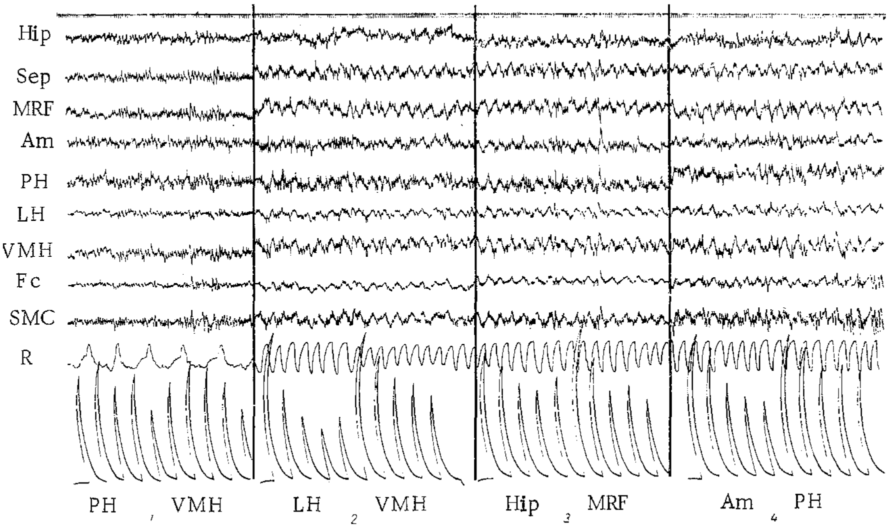

Fig. 2. Time course of changes in cat EEG during immobilization with EDS (4th day). 1) Background EEG, 2) immediately after EDS, 3) 15 min, 4) 30 min after EDS. R) Respiration. Remainder of legend as to Fig. 1.

EXPERIMENTAL METHOD

Chronic experiments were carried out on five cats weighing 3.0-3.5 kg on a model of combined emotional stress. The animals were immobilized in constraining cages, but the head protruded through a narrow opening on the front panel of the cage, and was thus outside it. Electrodermal stimulation (EDS) of the cat's limb, brought out through the hind panel of the cage, was applied in the form of single, aperiodic square pulses with the following parameters: voltage 40-50 V, pulse duration 1 sec, mean frequency 1 pulse/min for 10 min. Four or five experiments, carried out daily for 1 week, constituted a series. Blood for hormone assay was taken through a catheter inserted beforehand into the jugular vein, during the 3-4 days before the experiment began, 4 h after it began, and 1 h after it ended. Electrical activity of the brain structures was recorded on a 17-channel electroencephalograph (Nihon Kohden, Japan). Electrodes for deriving the EEG were made from nichrome wire 0.3-0.5 mm in diameter. A mono-

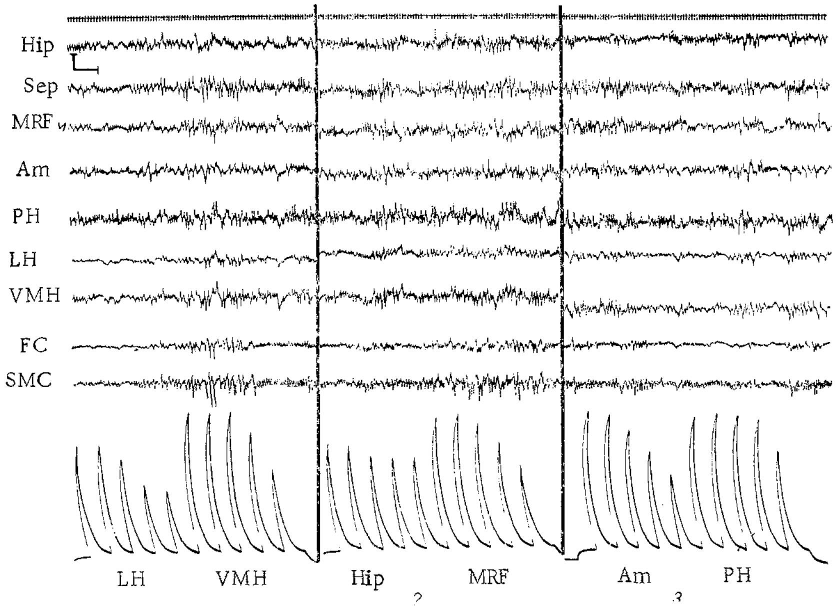

Fig. 3. Time course of changes in cat EEG 2 days after end of 4-day immobilization with EDS. Background recording. 1) During 1st h, 2) 2nd h, 3) 3rd h. Remainder of legend as to Fig. 1.

polar method was used. The subcortical electrodes were inserted in accordance with coordinates taken from a stereotaxic atlas of the cat brain [11]. The EEG was analyzed by means of a two-channel wide-band integrator (Nihon Kohden). Thyroxine in the blood plasma was assayed by a radioimmunochemical method, using special kits (Corning), according to the instructions supplied. Student's table was used for statistical analysis of the data.

EXPERIMENTAL RESULTS

Background electrical activity of the cortex and deep brain structures was recorded initially under unrestrained conditions for 2-3 days. Since the animals were first accustomed to the experimental situation, their background EEGs were quite stable. Electroencephalographic activity with a uniform distribution of both slow and high-frequency waves was recorded in the deep brain structures. Meanwhile, as a rule, high-frequency low-amplitude discharges predominated in the sensomotor cortex.

On the 1st day of the experiment (Fig. 1) immobilization alone without EDS initially evoked activation in the posterior hypothalamic nucleus, in which, against a background of an increase in power of discharges of all rhythms, the β rhythm became predominant. The mesencephalic reticular formation and ventromedial hypothalamic nucleus were activated later: The amplitude of the θ rhythm in these structures was increased. Soon after EDS the power of the discharges of all rhythms was increased in all brain structures, and against this background "bursts" of slow high-amplitude pointed waves began to appear and continued for 10-20 sec. During the experiment the frequency and duration of these periods of synchronization increased for a period of 4 h, but for an hour after it ended they disappeared in some animals, although in others they continued to be recorded. In the posterior hypothalamic nucleus high-amplitude epileptiform discharges persisted although their frequency was reduced. Similar changes were observed in brain electrical activity during the 2nd day of the experiment.

On the 3rd and 4th days of the experiment short and relatively frequent cycles of "bursts" of slow waves were recorded in the background EEG already. After EDS, against the background of quickened respiration, the power of discharges of all waves was again increased in all brain structures with predominance of the θ rhythm among them (Fig. 2).

Investigation of thyroxine secretion accompanying emotional stress showed a significant increase in its value not only during all 4 days of the experiment, but also 2 days after its end, when the animals had returned to the animal house. Only one cat (Table 1) was found to give a very stable response to stressors. The level of thyroxine secretion in this animal was high only on the 1st day of the experiment, and on subsequent days of the experiment and after it had ended it varied within the limits of the background value.

TABLE 1. Plasma Thyroxine Concentration in Cats with Chronic Emotional Stress (in ng/ml)

Animal No.	Background	1st day				2nd day				3rd day				4th day				2nd day after end	
		after 4 h of EDS	change, in %	1 h after end of EDS	change, in %	after 4 h of EDS	change, in %	1 h after end of EDS	change, in %	after 4 h of EDS	change, in %	1 h after end of EDS	change, in %	after 4 h of EDS	change, in %	1 h after end of EDS	change, in %	back-ground	change, in %
1	28,4	45,1	59	66,5	134	32,8	16	25,7	—9	30,8	9	35,8	25	35,0	23	35,9	26	38,2	35
2	16,5	27,3	66	25,8	56	26,2	59	27,1	64	20,0	21	21,2	29	—	—	18,4	12	22,1	34
3	24,2	33,5	38	26,3	9	23,3	-9	26,3	9	26,1	8	26,3	9	25,3	5	25,2	4	25,0	4
4	35,3	49,2	39	45,1	28	46,6	32	46,5	32	49,2	39	39,4	12	44,2	25	45,0	28	43,2	22
5	18,2	25,4	40	10,0	—45	33,0	81	19,2	6	24,0	32	23,0	26	26,6	46	23,0	26	22,0	21
t		6,893		1,568		3,178		1,948		3,217		5,448		4,519		3,031		3,559	
P	<0,01			>0,2		<0,05		>0,2		<0,05		<0,01		<0,05		<0,05		<0,05	

Comparison of the hormonal reactions with brain electrical activity revealed correlation between the functional state of the CNS and the level of thyroxine secretion.

Similar correlation also was found 2 days after the end of a 4-day period of stress of the animal. In this after-period, just as previously, background EEG activity was recorded under unrestrained conditions. As Fig. 3 shows, cycles of bursts of slow waves appeared periodically in the EEG, although they were appreciably shorter in duration than on the 4th day of the experiment. Frequency analysis under these circumstances showed an increase in power of discharges of all waves in the posterior hypothalamus, but predominantly in the region of slow waves in the other structures. During this period the blood hormone level remained significantly high.

In a discussion of the presence of "burst" activity under unrestrained conditions during the after-period (2 days after the end of the experiment) it can be tentatively suggested that it reflects afferentations related to the experimental situation in the bioelectrical pattern of the brain. However, considering that the thyroxine level in blood taken from the animals in the animal house still remained high, there is reason to suppose that the functional state of the CNS also remained under stress although the animal was leading a normal way of life.

Neurophysiological analysis of emotional stress revealed the trigger role of the posterior hypothalamus. This nucleus not only is activated first, and then involves the other brain formations in this process, but it also returns after all the other structures to its initial functional state, evidence that this brain formation plays an important role in the mechanisms of development and long-term maintenance of "burst" activity. The writers previously demonstrated the role of this nucleus in maintaining a high level of hormonal secretion under conditions of defensive activity [1]. Analysis of the time course of the EEG and hormonal secretion in chronic stress also revealed that cycles of "burst" activity arising in the background EEG after the 3rd day of stress become "static" in character and continue to be recorded for several days after the end of the experiments; a particularly important feature from our point of view is that this phenomenon is accompanied by high hormonal secretion.

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