EFFECT OF NOISE STRESS ON QUANTITATIVE CHARACTERISTICS OF RAT BRAIN SYNAPSES

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Noise, used as a stress factor, is known to induce chromatolysis in neurons of the rat auditory cortex [1, 2, 3]. Since noise exerts its action on cortical neurons through the synaptic apparatus, it was decided to study how the quantitative characteristics of the brain synapses of animals change under these circumstances.

EXPERIMENTAL METHOD

Experiments were carried out on 12 male albino rats weighing 200–220 g. The experimental animals (three in a group) were exposed to the action of sound for 17 h daily for 1, 2, and 3 weeks. The power of the sound was 80–90 dB above the threshold of audibility of the human ear, and the frequency range was 350–3500 Hz. The noise was interrupted in character: noise for 2 sec, rest for 1 sec; three control animals were kept under normal animal house conditions. The auditory and sensomotor cortex – areas 41 and 6 in Krieg's atlas [8] – served as the test object. After rapid decapitation on the last day of the experiment, pieces of cortex were removed perpendicularly to the pial surface of the hemispheres and fixed in 5% glutaraldehyde solution in phosphate buffer, and then stained in a 1% solution of phosphotungstic acid (PTA) in absolute alcohol [7]. The tissue was embedded in Araldite. For each animal three blocks were taken at random and sections were cut on the LKB–III Ultratome.

The number of synapses was counted directly from the screen on the IEM 100B electron microscope. An area of section equal to 13.5 μ^2 was studied on the screen measuring 6×9 cm, under a magnification of 20,000 (Fig. 1). The number of synapses was counted during random movement of the sections. The forbidden lines rule was used when counting. The number of synapses in five fields of vision (67.5 μ^2) was regarded as a single result m. Samples of 10m were taken for the upper layers I–IV and for the lower layers V–VI in the auditory and sensomotor cortex. These values formed a variance series with normal distribution of the members. The arithmetic mean (X) for this series was then calculated and its confidence interval L determined by Strelkov's equation $L = a \times R$, where a is the amplitude of the variance series, equal to the difference between the highest and lowest values of its members, and R is Strelkov's coefficient for the given number of members [5].

EXPERIMENTAL RESULTS

The results at each time, compared with the control, are given in Table 1. Normally the number of synapses in the auditory cortex is significantly higher in its upper levels. In the sensomotor cortex there are no significant differences. After exposure to sound for 1 week the number of synapses was significantly increased in all four zones studied. After exposure to sound for 2 weeks the number of synapses in the lower layers of the auditory and upper layers of the sensomotor cortex was significantly reduced, whereas in the upper layers of the auditory and lower layers of the sensomotor cortex it remained at the same level as after 1 week.

Exposure to sound for 3 weeks led to a significant increase in the number of synapses (by 200–230%) in the auditory cortex and upper layers of the sensomotor cortex (by 180%). In layers V–VI of the sensomotor cortex the number of synapses was 130% of normal.

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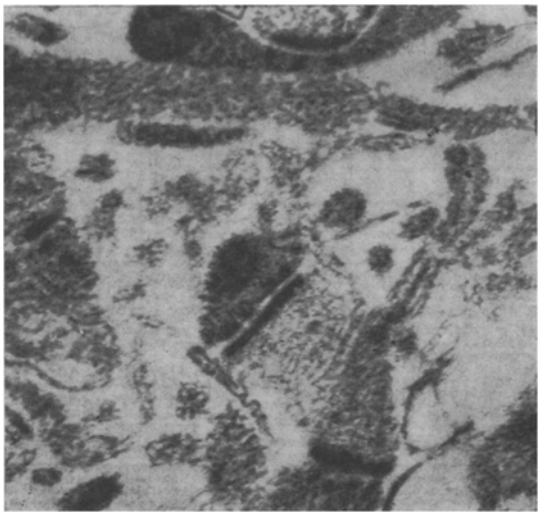

Fig. 1. Active zones of synapses in neuropil of rat cerebral cortex. Stained with PTA, magnification 20,000.

TABLE 1. Number of Synapses in Different Layers of Cerebral Cortex of Rats Exposed to Noise ($\bar{X} \pm L$)

Experimental conditions	Auditory cortex		Sensomotor cortex	
	layers I–IV	layers V–VI	layers I–IV	layers V–VI
Control	8,6±0,7	7,0±0,5	10,5±1,2	9,5±0,6
noise:				
1 week	12,7±0,8	10,3±1,0	17,5±1,5	12,7±1,6
2 weeks	11,5±1,8	7,8±0,9	13,2±0,9	11,3±1,7
3 weeks	17,4±1,9	16,3±2,1	19,0±1,4	12,5±1,3

Under normal conditions the different layers of the auditory and sensomotor cortex thus do not differ significantly. The action of sound causes a significant increase in the number of synapses in all layers of the cortex studied, evidence of increased activation of synapses. Neurons of cortical layers I–IV and V–VI reacted differently to noise. The number of synapses was greater in layers I–IV than in layers V–VI, in both the auditory and the sensomotor cortex. The reason evidently is that neurons receiving afferent impulses and exposed to a greater functional load in these experiments are located in the upper layers (III, IV) [4, 6].

The reliability of this morphological criterion (the number of synapses per unit area of section) and the possibility of its use to assess the functional state of neurons were demonstrated by electron microscopy. The results of single measurements on all three animals in the group were regarded as a single variance series of 30 variables for each region. The results suggest that prolonged excitation of the nervous system by noise leads to activation of many synaptic junctions and also, possibly, to the formation of new synapses. Increased activation of synapses leads to exhaustion of the internal resources of the nerve cells and to the development of total chromatolysis.

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