REACTION OF THE NERVE CELLS OF THE BRAIN TO A PROLONGED INCREASE IN STIMULI FROM PERIPHERAL RECEPTORS

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The reaction of the nerve cells of the brain to prolonged stimulation of the peripheral receptors has not yet been accurately determined. Agduhr [3] described an increase in the area of the cruciform gyri and a deepening of the cruciform fissure in the brain of adult cats carrying out increasing numbers of movements daily for many days. By comparison with control animals sitting in confined cages, in the experimental animals an increase was observed in the number of giant pyramidal cells and in the white matter in the region of the cruciform gyri.

Different results were obtained by Edström [4], in whose experiments 7 guinea pigs carried out an increasing number of movements on a belt moving at the velocity of 0.8 m/sec. For a period of 12 days the animals ran for 20 minutes (2 periods, each of 10 minutes) daily. For the next 5 days the running time was extended to 30 minutes (2 periods each of 15 minutes); for 2 days the animals were made to run for 90 minutes daily (3 periods, each of 30 minutes) and, finally, for 10 days the guinea pigs ran for 135 minutes daily (3 periods, each of 45 minutes). Thus the total running time in the course of 29 days was 32 hours. The guinea pigs were sacrificed 18 hours after the experiment. The cervical enlargement of the spinal cord was fixed in Carnoy's fluid and sections were stained with methylene blue.

In his studies of the histological sections Edstrom found no essential differences in the dimensions of the nerve cells of the anterior horn in the animals which had run for long periods on the moving belt and the control animals.

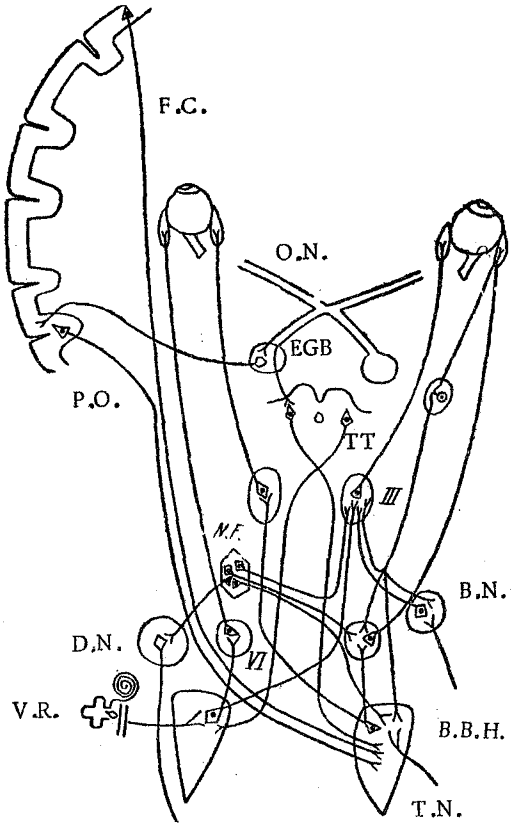
We studied the reaction of the nerve cells of the triangular nucleus and also the nerve cells of the nucleus of the oculomotor and abducens nerves of adult rabbits to prolonged stimulation of the vestibular apparatus.

EXPERIMENTAL METHOD

The vestibular receptors were stimulated by revolving the rabbits on a platform in a horizontal plane at the rate of 1 revolution in 2 seconds. At the beginning of the experiment the animals made 15 revolutions in a clockwise direction and, after a pause of 2 minutes, 15 revolutions in an anticlockwise direction. In the course of each hour the rabbits made 75 clockwise and 75 anticlockwise revolutions. In each experiment the vestibular receptors were thus stimulated for 5 minutes. The experiment was repeated 2 or 3 times daily, at 11.00, 13.00, and 15.00 hours or at 11.00 and 14.00 hours.

The vestibular apparatus was stimulated in 6 adult rabbits for 18-19 days. The animals were decapitated while awake 25-48 hours after the end of the last experiment. The controls were 7 adult rabbits of the same breed and weight (3-3.5 kg), which also were decapitated in a waking state. The brain was fixed in 7% formalin solution. The brain stem was embedded in paraffin wax; continuous series of sections were cut from the blocks to a thickness of 8 μ and stained by Nissl's method.

According to B. N. Klosovskii's investigations [2], during rotation in a horizontal plane stimuli from the receptors of the vestibular apparatus pass mainly to the nerve cells of the triangular nucleus. Accordingly, to study the reaction of the nerve cells to a prolonged increase in the flow of impulses from the periphery, of all the nuclei of the vestibular nerve situated in the medulla we chose only the cells of the triangular nucleus as test objects.



Scheme of the connections of the nuclei of the vestibular nerve with the nuclei of the oculomotor nerves and the cortex for horizontal movement of the eyes (after Klosovskii). VR) Receptors of the vestibular apparatus; TN) triangular nucleus; BN) nucleus of Bekhterev; DN) nucleus of Deiters; VI) nucleus of the abducens nerve; III) nucleus of the oculomotor nerve; EGB) external geniculate body; ON) optic nerve; FC) fronto-cortical pathway for eye movements; PO) parieto-occipital pathway for eye movements; NF) nucleus fastigii; TT) tecto-spinal tract.

We know from B. N. Klosovskii's findings [1, 2] that the vestibular receptors are also the main source of stimuli for the nerve cells of the nucleus of the oculo-motor and abducens nerves; these stimuli reach the latter cells via the nerve cells of the triangular nucleus (see Fig. 1).

The nerve cells of the triangular nucleus are the second intermediate neuron in the path of movement of excitation from the receptors of the vestibular apparatus to the nuclei of the oculomotor nerves. At the same time, the cells of the nucleus of the oculomotor and abducens nerves are motor neurons. The sensory neuron of this reflex arc (the nerve cells of the superior and inferior vestibular ganglia) is situated outside the brain. When studying the reaction of the nerve cells of the brain to prolonged stimulation of the peripheral receptors, we therefore restricted ourselves to investigating the intermediate and motor neurons.

To elucidate the consequences of prolonged stimulation of the peripheral receptors in the triangular nucleus and the nucleus of the oculomotor and abducens nerves, we measured 50 large somatochrome cells; the maximal length and weight of the cell body were determined. These values were multiplied together to give the area of the outline field of the nerve cell in μ^2. This area does not represent the true area of the cell profile, but for the detection of a relative change in the size of the body of nerve cells of the same nucleus in experimental and control animals, it is not necessary to obtain the true dimensions of the profile field. This applies equally to the determination of the area of this field, which we calculated as the product of the axes of the nucleus.

On the basis of measurement of 50 large nerve cells or their nuclei, we deduced a mean value for each animal. The results were treated by the method of variational statistics.

Since the rabbits were rotated alternately clockwise and anticlockwise, stimuli reached the nerve cells on both sides. For purposes of measurement we therefore used the large nerve cells of the above-mentioned nuclei on both sides of the brain stem.

We measured not only the large nerve cells of the triangular nucleus, but also cells of the nucleus of the oculomotor and abducens nerves, in sections of which the nucleus contained a nucleolus. This indicated that the section passed through the middle of the cell body. Another essential condition was that the cells were measured in the active state. This was judged by the following signs: absence of swelling; even distribution of chromatin in large or small granules in the cytoplasm; the nucleus situated in the center of the nerve cell; well-marked tension of the karyolymph, translucent on staining; the presence of a compact, intensively stained nucleolus.

EXPERIMENTAL RESULTS

Our results are given in Tables 1 and 2. The absence of figures in certain columns of these tables indicates that in that particular nucleus of the experimental or control animal we were unable to find large nerve cells in an active state suitable for measurement.

TABLE 1. Size of the Body of Nerve Cells (in μ^2) in Animals Exposed to Prolonged Stimulation of the Vestibular Apparatus and in Control Animals

Nucleus	Experimental animals						
	1	2	3	4	5	6	Mean
Triangular	—	218.88	—	167.04	201.50	206.44	198.46 ± 11.05
Of the oculomotor nerve	371.68	481.57	428.75	431.50	402.60	520.70	439.46 ± 22.1
Of the abducens nerve	413.18	415.44	465.81	415.58	415.00	480.92	434.16 ± 12.49

Nucleus	Control animals							
	1	2	3	4	5	6	7	Mean
Triangular	—	—	—	105.78	117.40	110.24	110.24	110.87 ± 11.6
Of the oculomotor nerve	293.60	334.42	334.36	311.72	—	346.86	356.54	329.6 ± 9.4
Of the abducens nerve	307.74	—	—	316.68	—	314.82	350.46	322.42 ± 9.50

TABLE 2. Size of the Nucleus of Nerve Cells (in μ^2) in Animals Exposed to Prolonged Stimulation of the Vestibular Apparatus, and in Control Animals

Nucleus	Experimental animals						
	1	2	3	4	5	6	Mean
Triangular	—	51.96	—	48.88	52.60	51.82	51.32 ± 0.83
Of the oculomotor nerve	75.60	66.48	70.80	61.94	74.70	75.12	70.77 ± 2.28
Of the abducens nerve	89.78	67.55	72.40	66.28	65.64	69.06	71.78 ± 4.03

Nucleus	Control animals							
	1	2	3	4	5	6	7	Mean
Triangular	—	—	—	53.04	44.44	38.66	42.06	44.55 ± 3.06
Of the oculomotor nerve	63.38	62.56	61.82	69.78	—	64.16	64.16	63.76 ± 1.29
Of the abducens nerve	63.94	—	—	62.90	—	72.40	58.20	61.36 ± 2.95

Comparison of the individual and mean dimensions of the body of the nerve cells of the triangular nucleus in the experimental and control rabbits shows that the cells in the animals exposed to prolonged stimulation of the vestibular apparatus were considerably enlarged (by 79%). The nerve cells of the nucleus of the oculomotor and abducens nerves were enlarged by 32 and 34.6% respectively under the influence of prolonged stimulation from the peripheral receptors.

In contrast to the body, in the nuclei of the nerve cells of the triangular nucleus and the nucleus of the oculomotor nerve the changes in size were not so obvious. The nuclei of the nerve cells of the triangular nucleus in the experimental rabbits were enlarged by only 15% compared with those in the control animals. In the nucleus of the oculomotor nerve, the corresponding enlargement in the experimental animals was 21%. There was no difference in the size of the nuclei of the nerve cells in the nucleus of the abducens nerve in the experimental and control animals.

Prolonged stimulation of the vestibular apparatus in adult animals thus resulted in hypertrophy of the body of the intermediate and motor nerve cells, receiving nervous impulses from the receptors undergoing stimulation. The nuclei of these cells were unchanged or enlarged to a much lesser degree than their bodies.

LITERATURE CITED

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