FUNCTIONAL PROPERTIES OF "RETICULAR" NEURONS OF THE FROG MEDULLA

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UDC 597.828-118

Neurons which, by the type of their responses to stimulation, their polyvalency, and certain other properties, can be regarded as belonging to the reticular system have been found in the magnocellular nucleus of the frog medulla. These neurons have diffuse excitatory (predominantly) and inhibitory influences on elements of the tectum mesencephali.

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Despite considerable published data on the influence of subcortical structures of the reticular formation on higher and lower levels of the mammalian brain [1, 2, 4, 10, 11, 15, 16-18, 20], no precise experimental data concerning the initial stage of development of the reticular formation in phylogenesis can be found in the literature with the exception of morphological investigations [6, 9, 14] revealing only structural features of the cells and their topographic relationship to various parts of the brain.

We therefore decided to study the "reticular" properties of neurons of the magnocellular nucleus of the frog medulla.

EXPERIMENTAL METHOD

The experiment was carried out on frogs (Rana ridibunda L.) immobilized by intraperitoneal injection of tubocurarine in a dose of 1 mg/100 g body weight. Discharges of the cells of the optic lobe and magnocellular nucleus of the medulla were recorded by two liquid microelectrodes located in the corresponding parts of the brain. Electrical stimuli were applied to the magnocellular nucleus by means of a unipolar silver electrode, with tip 20 μ in diameter, from a "Multistim" stimulator. The potentials were recorded on a "Disa" 3-channel electromyograph. The photic stimulus was supplied by an incandescent lamp giving an intensity of illumination at the level of the eye surface of 600-700 lx. Altogether 34 experiments were performed, during which the discharges of 112 neurons of the optic lobe and 145 neurons of the magnocellular nucleus of the medulla were recorded.

EXPERIMENTAL RESULTS AND DISCUSSION

Of 52 (hypothetically "reticular") neurons of the medulla, 36 possessed polyvalent sensitivity, i.e., they were excited during electrical stimulation of various areas of skin (Fig. 1a) by photic (Fig. 1b) and acoustic (Fig. 1c) stimulation, and also by direct electrical stimulation of the region of the magnocellular nucleus and ascending tracts of the spinal cord. In the character of their response to electrical stimulation of the ascending tract of the spinal cord, the neurons of the magnocellular nucleus could be divided into two groups: those responding by a short discharge consiting of 1-5 impulses with a latent period varying from 1 to 20 msec (36 units) and those responding by tonic, prolonged activation lasting from 500 msec to 2 sec (16 units). The latent period of the latter responses varied from 5 to 100 msec. Stimulation of the region of the magnocellular nucleus not only evoked a response of the tectum mesencephali neurons, but also significantly modified their response to photic stimulation. If a cell of the tectum mesencephali gave a response of the "on-off" type of excitatory effect to light, against the background of electric stimulation a marked increase in frequency of the discharge or of its duration was observed (Fig. 1). If the tectum mesencephali cells responded to photic stimulation by inhibition, against the background of electrical stimulation of the magnocellular nucleus either the slowing became more marked or the inhibitory period in impulse activity was prolonged. Under these circumstances it was often possible to discover in the magnocellular nucleus a

Department of Human and Animal Physiology and Laboratory of Biophysical Problems, Rostov University (Presented by Academician V. V. Parin). Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny, Vol. 66, No. 7, pp. 9-11, July, 1968. Original article submitted March 23, 1967.

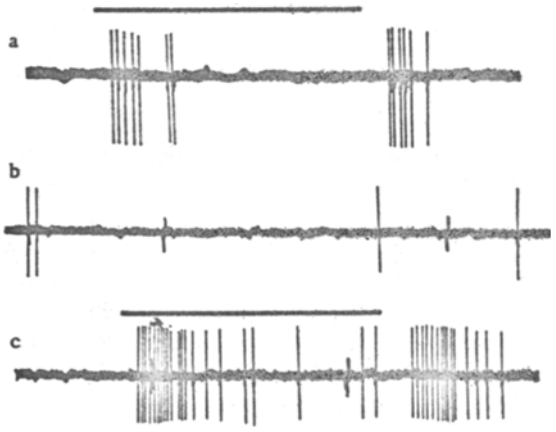

Fig. 1. Responses of a neuron of the magnocellular nucleus of the medulla to electrodermal (a), photic (b), and acoustic stimulation (c).

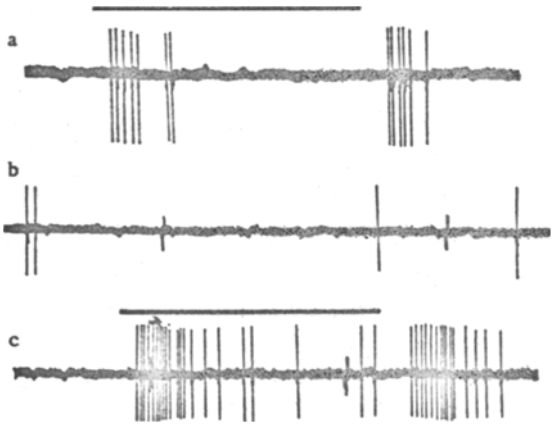

Fig. 2. Responses of neuron of the frog tectum mesencephali to photic stimulation of the contralateral eye (a), to electrical stimulation of the magnocellular nucleus of the medulla (b), and to photic stimulation of the contralateral eye against a background of infrequent rhythmic electrical stimulation of the magnocellular nucleus of the medulla (c).

cell or system of cells responsible for bringing about this facilitatory effect on the cells of the tectum mesencephali.

During investigation of six neurons, reciprocal antagonistic relationships were found, i.e., excitation of a neuron of the magnocellular nucleus led to inhibition of the response of the tectum mesencephali cell to photic stimulation, or vice versa. Consequently, the system of "reticular" neurons of the magnocellular nucleus of the medulla includes neurons exerting not only an ascending excitatory, but also an ascending inhibitory influence. Despite the low level of differentiation of the system of "reticular" neurons at the amphibian stage of development [5], it is nevertheless possible to identify cells exerting both excitatory and inhibitory influences. Since inhibitory effects are a later acquisition in the course of evolution [3], at the stage of development of the amphibian nervous system as a rule excitatory ascending influences are present.

Some of the neurons of the magnocellular nucleus of the frog medulla which we investigated thus possess a number of properties (type of responses to stimulation, polyvalency, facilitatory influences on responses of higher sensory neurons) which many authors [7, 8, 12, 13, 19, 20] regard as characteristic features of reticular neurons, so that we can conclude that these are cells of the reticular formation which appear and attain a certain level of development at the amphibian stage.

LITERATURE CITED

1. P. K. Anokhin, in: Electroencephalographic Investigation of Higher Nervous Activity [in Russian], Moscow (1962), p. 241.
2. R. A. Durinyan, Vestn. Akad. Med. Nauk SSR, No. 1, 68 (1966).
3. A. B. Kogan, in: Reflexes of the Brain [in Russian], Moscow (1965), p. 103.
4. S. P. Narikashvili, S. M. Butkhuzi, and É. S. Moniava, in: Current Problems Concerning Activity and Structure of the Central Nervous System [in Russian], Tbilisi (1965), p. 39.
5. E. K. Sepp, History of Development of the Nervous System of Vertebrates [in Russian], Moscow (1959).
6. G. H. Bishop, in: Reticular Formation of the Brain [Russian translation], Moscow (1962), p. 366.
7. A. Fessard, in: Brain Mechanisms and Consciousness, Paris (1954), p. 200.
8. A. Fessard, in: Sensory Communication, New York (1961), p. 585.
9. C. J. Herrick and G. H. Bishop, in: Reticular Formation of the Brain [Russian translation], Moscow (1962), p. 314.
10. H. Jasper, Electroenceph. Clin. Neurophysiol., 1, 405 (1949).
11. H. Jasper, in: Brain Mechanisms and Consciousness, Paris (1954), p. 374.
12. R. Jung, in: Sensory Communication, New York (1961), p. 627.
13. R. Jung, in: Reticular Formation of the Brain [Russian translation], Moscow (1962), p. 374.
14. C. U. A. Kappers, G. C. Huber, and E. C. Crosby, The Comparative Anatomy of the Nervous System of Vertebrates Including Man, New York (1936).

15. H. Magoun, in: Brain Mechanisms and Consciousness, Paris (1954), p. 1.
16. H. Magoun, The Waking Brain [Russian translation], Moscow, (1965).
17. G. Moruzzi, in: Brain Mechanisms and Consciousness, Paris (1954), p. 24.
18. M. E. Scheibel and A. B. Scheibel, in: Reticular Formation of the Brain, London (1957), p. 31.
19. M. E. Scheibel and A. B. Scheibel, Arch. Ital. Biol., 103, 300 (1965).
20. M. E. Scheibel and A. B. Scheibel, Brain Res., 1, 250 (1966).