UNIT ACTIVITY IN THE HIPPOCAMPUS AND CORTICOID PLATE

T. P. Shlyafer, N. N. Vasilevskii, and V. K. Kruchinin

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Unit responses in the hippocampus and corticoid plate of hens have more features in common than differences. The mechanisms of cortical and hippocampal unit responses to ecologically adequate (photic) stimuli are more perfectly formed in hens than responses to less adequate (nociceptive and acoustic) stimuli

Unit responses of the archicortex and neocortex have been the subject of numerous investigations [2, 3, 7-10].

Since the phylogenetic aspect of this problem has not yet been adequately investigated, the present investigation was carried out to study unit activity in the hippocampus and corticoid plate of hens, the brain of which has a more primitive morphological structure than in animals at a phylogenetically higher level [5].

EXPERIMENTAL METHOD

White Leghorn hens were immobilized with flaxedil (0.9 mg/kg) and artificial respiration applied. An incision was made in the scalp and a hole drilled for the microelectrode under local anesthesia (2% procaine). The hen was placed on a frame and the head fixed by a special clamp. The glass microelectrode was lowered into the corticoid region of the hemisphere. For inserting the microelectrode into the hippocampus, coordinates A 8-9 from the atlas of Tienhoven and Juhasz [11] were used. The potentials were fed through a transistorized ac amplifier to a type MPO-2 oscilloscope. Unit activity was counted by means of a ChZ-4A frequency meter. The following stimuli were used: a pure tone (2000 Hz), 4-6 pinpricks of the skin of the thigh, and diffuse illumination of the eyes (300 lx). The duration of action of the stimuli was 6 sec and they were applied at intervals of 6-30 sec. Altogether 122 neurons were tested: 66 in the Lippocampus and 56 in the corticoid plate of the hens' brain.

EXPERIMENTAL RESULTS

The mean frequency of background activity of the tested neurons in the corticoid plate and hippocampus was the same (11 ± 0.09 and 13 ± 0.1/sec respectively), although the most typical background had a frequency of 6-10/sec. However, neurons of the hippocampus and corticoid plate responded differently to sensory stimuli. For example, 61% of corticoid plate units responded to acoustic stimulation, 77% to nociceptive, and 80% to photic. Of the total number of hippocampal units tested, 70% responded to acoustic stimulation, 80% to nociceptive, and 63% to photic. These results suggest that neurons of the corticoid plate and hippocampus receive afferent impulses from different sources. It also follows from these results that in hens many cells of the corticoid plate respond to photic stimulation. A possible explanation of this fact is that for birds the visual stimulus is ecologically more active [1, 4]. Cells of the corticoid plate and hippocampus are not always specific. This was shown by the fact that most neurons of the hippocampus (85%) and corticoid plate (90%) responded to 2 or 3 stimuli. Only occasional neurons responded to 1 stimu-

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TABLE 1. Distribution of Excitatory and Inhibitory Responses (in percent) to Photic, Acoustic, and Nociceptive Stimulation of Neurons of Corticoid Plate and Hippocampus

Test object	Photic stimulation			Acoustic stimulation			Nociceptive stimulation		
	neurons discharging more frequently	neurons discharging more slowly	neurons discharging more frequently and more slowly	neurons discharging more frequently	neurons discharging more slowly	neurons discharging more frequently and more slowly	neurons discharging more frequently	neurons discharging more slowly	neurons discharging more frequently and more slowly
Neurons of corticoid plate	70	20	10	50	33	17	67	33	0
Hippocampal neurons	31	51	18	53	30	17	50	25	25

lus. Predominance of polynodal cells in the corticoid plate and hippocampus thus suggests an associative type of organization of the receptive fields of these structures.

Comparison of the character of unit responses in the hippocampus and corticoid plate showed no sharp differences between them (Table 1). Most cells responded to the action of the stimuli (except photic) by an increase in firing rate. The hippocampal neurons responded to photic stimulation mostly by a decrease in frequency of background activity, while cells of the corticoid plate responded by an increase in frequency. In 88% of cases, neurons of the hippocampus and corticoid plate responded to stimuli of different modalities. This suggests that in the corticoid plate and hippocampus of the hen's brain there are many cells on which stimuli of different modalities converge. A trace from the action of the stimuli remained for a long time on cells of both the corticoid plate and the hippocampus. After withdrawal of the photic stimulus, 98% of cells of the corticoid plate and 83% of hippocampal cells showed an aftereffect. An aftereffect from nociceptive stimulation was observed in 75% of cells of the corticoid plate and 83% of hippocampal cells.

The formation of the unit response was influenced not only by the character of the stimulus, and the time interval between stimuli, but also by the functional state of the cell at the time of stimulation. This was demonstrated by the correlation observed between the initial background frequency and the amplitude of the response to stimulation. For example, the coefficient of correlation between the initial background frequency of the hippocampal neurons and the amplitude of the response to acoustic stimulation was 0.99 ($P=0.01$). The coefficient of correlation between the initial background frequency of cells of the corticoid plate and the amplitude of the response was 0.98 ($P=0.01$). These investigations thus showed that unit responses of the hippocampus and corticoid plate have more features in common than differences, which cannot be said of unit responses in the archicortex and neocortex of animals at a higher level of phylogenetic development [6]. It was also discovered that at the level of neuronal organization of the corticoid plate and hippocampus, adaptation to the action of the ecologically most adequate stimulus for birds (visual) is exhibited. The features of this adaptation to the neuronal mechanism can be seen in the fact that neurons of the corticoid plate were recruited by photic stimuli into excitatory responses, while hippocampal cells were recruited into inhibitory responses. A different relationship was observed with the unit responses of the hippocampus and corticoid plate to less adequate stimuli (nociceptive and acoustic). Usually cells of the corticoid plate and hippocampus gave similar types of responses to these stimuli (Table 1). In animals with a more highly developed central nervous system (guinea pigs, rabbits), unit activity in the neocortex differed from that in the hippocampus [3, 6]. Consequently, the mechanisms of unit responses in the cortex and hippocampus of hens to ecologically adequate (photic) stimuli are more perfectly formed than to less adequate (nociceptive and acoustic) stimuli.

LITERATURE CITED

1. V. I. Bagryanskii, in: Investigations into the Evolution of Nervous Activity [in Russian], Leningrad (1959), p. 13.
2. N. N. Vasilevskii, Byull. Éksperim. Biol. i Med., No. 1, 9 (1966).
3. N. N. Dzidzishvili, in: Structure and Function of the Archipaleocortex [in Russian], Moscow (1968), p. 291.
4. T. M. Zagorul'ko, in: Problems in the Comparative Physiology and Pathology of Higher Nervous Activity [in Russian], Leningrad (1964), p. 155.

5. L. A. Orbeli, in: Evolution of Functions of the Nervous System [in Russian], Leningrad (1958), p. 7.
6. T. P. Shlyafer, Fiziol. Zh. SSSR, No. 3, 318 (1970).
7. V. E. Amassian, in: Internat. Rev. Neurobiol., 3, 68 (1961).
8. J. D. Green and X. Machne, Am. J. Physiol., 181, 219 (1955).
9. E. R. Kandel and W. A. Spencer, J. Neurophysiol., 24, 243 (1961).
10. V. B. Mountcastle, J. Neurophysiol., 20, 408 (1957).
11. A. von Tienhoven and L. P. Juhasz, J. Comp. Neurol., No. 2, 185 (1962).