Cytochemical Characteristics of the Brain in Rats Differing in Active Avoidance Learning Ability

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Brain structures were examined in two mouse strains differing in active avoidance learning in a shuttle box. Protein content and concentration, area of the cytoplasm and nuclei of neuron in layers III and V of the sensorimotor cortex were higher in rats with high learning ability. The detected morphochemical differences between the same brain structures of rats with high and low learning capacity can be attributed to this capacity.

Key Words: *rats with high and low active avoidance learning ability; brain; proteins; interferometry*

Genetic models allowing detection of the causal relationships between neurochemical and functional peculiarities of the nervous system and behavior have been widely used in physiology.

In our experiments two rat strains selected by their ability for active avoidance (AA) conditioning in a shuttle box [5] were used.

The purpose of our study was to detect morphochemical features of brain structures in rats with high and low AA learning ability (HLA and LLA, respectively) differing in their behavior.

MATERIALS AND METHODS

Wistar rats weighing 200±10 g (I. P. Pavlov Institute of Physiology, Russian Academy of Sciences) were examined using behavioral tests. After physiological experiments the animals were narcotized with Nembutal and perfused for 10 min with normal saline and for 40 min with 1.19% sodium sulfide and 5% polyvinylpirrolidone in 70% ethanol. The brain was fixed in Carnoy fluid, routinely treated for histological analysis, embedded in paraffin, and 7-μ sections were prepared [3].

Neurons of the sensorimotor cortex (layers III and V), caudate nucleus, and hippocampus (CA3 field) were examined.

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Dry weight of the compact matter of the neuronal cytoplasm and nuclei were measured by interferometry on a BINAM-L212 microscope and protein concentration reflecting the function of the central nervous system [1,6] was estimated. Simultaneously profile fields of the neuron cytoplasm and nuclei were measured using an MOB-1-15 ocular micrometer.

The results were processed using Protein software created at the Laboratory of Cytochemistry, Institute of Brain Research, Russian Academy of Medical Sciences. Preparations stained with cresyl violet by Viktorov's method served as morphological control [2].

RESULTS

Neurons of the sensorimotor cortex (layers III and V) were larger and protein content and concentrations in these neurons were higher in HLA rats (Table 1), while in the caudate nucleus and hippocampus these morphological parameters were higher in LLA rats (Table 1).

Hence, the sensorimotor cortex (layer III with predominantly associative neurons and layer V with predominantly efferent projection neurons), hippocampal CA3 field neurons (key structure of the limbic system), and caudate nucleus neurons are different in animals selected by AA conditioning capacity.

Previously we discovered low content and concentration of protein in layers III and V of the sen-

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TABLE 1. Interferometry of the Brain in Rats with High (HLA) and Low (LLA) AA Learning Ability ($M \pm m$)

Parameter	HLA	LLA	HLA/LLA, %
Cytoplasm area, μ^2			
layer III	59.860±0.092	54.38±0.82	+10.1
layer V	184.47±3.44	155.57±3.69	+18.6
caudate nucleus	22.63±0.30	35.76±0.43	-36.7
hippocampus	38.13±0.70	54.71±0.66	-30.3
Protein content in the cytoplasm, pg			
layer III	106.77±2.21	70.94±1.54	+50.5
layer V	377.45±8.43	241.39±7.77	+54.4
caudate nucleus	33.29±0.58	54.39±1.05	-38.8
hippocampus	26.36±0.63	55.26±0.94	-52.3
Protein concentration in the cytoplasm, pg/μ^3			
layer III	1.78±0.02	1.31±0.02	+35.9
layer V	2.04±0.02	1.53±0.02	+33.3 %
caudate nucleus	1.47±0.01	1.53±0.02	-4.0*
hippocampus	0.69±0.01	1.01±0.01	-31.7

Note. $p<0.01$ in all cases except *.

sorimotor cortex and high protein content in the caudate nucleus neurons [4] in August rats with low conditioning capacity sensitive to emotional stress [7]. Our findings suggest that the cortico-subcortical morphochemical ratios similar to those of August rats are also typical of LLA rats. Presumably, decreased conditioning capacity and decreased protein content in cortical neurons of LLA rats are interrelated. It seems that learning capacity as a genetic sign is determined by fine morphochemical characteristics of individual brain structures.

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