ELEMENTS OF NEURONAL ORGANIZATION AND CYTOARCHITECTONICS OF SPECIFIC AND NONSPECIFIC NUCLEI OF THE CAT THALAMUS

Z. V. Eliseeva

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By counting neurons and allowing for the size of the cell, it was found that three types of cells are represented in part of the posterior ventral nucleus the width of ten fields of vision: 34.7% are large cells (35-40 μ), 42.1% are medium-sized cells (20-25 μ), and 11.6% are small cells (10 μ). The large neurons are concentrated in the central part of the nucleus. In the direction of the ventral periphery a tendency is observed for their number to diminish. Dendrites of the large and, to some extent, of the medium-sized neurons are relatively short and highly ramified.

The centrum medianum is characterized by a uniform distribution of cells (approximately of the same size) throughout the volume of the nucleus. The long dendrites, with few branches, of these neurons may determine the polysensory character of this nucleus.

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Despite great advances in neurophysiology in the study of functions of the specific and nonspecific nuclei of the thalamus, many aspects of the organization of these structures still remain incompletely understood [1]. The difficulties in correct evaluation of the results can be attributed to the fact that so far insufficient attention has been paid to the study of the cytoarchitectonics [5, 6] and neuronal structure [7-9] of these nuclei.

In this paper the neuronal organization and cytoarchitectonics of the specific and nonspecific nuclei of the cat's thalamus are described from the comparative aspect, using as the example the organization of the posterior ventral nucleus (VP) and centrum medianum (CM) of the thalamus.

EXPERIMENTAL METHOD

To study the distribution of neurons in the nuclei, neurons were counted depending on the size of their cell body.

For this purpose, the number of cells was counted in sections stained by Nissl's method in the middle part of the frontal section through the particular nucleus (from the ventral border to the dorsal) in a strip the width of 10 fields of vision (400 ×). The outline of the neuron with all their processes was drawn from specimens stained by the Golgi – Kopsch method.

EXPERIMENTAL RESULTS

As Fig. 1, A shows, cells of medium and large size with clear outlines and well defined Nissl granules are predominant in the VP nucleus. Large neurons (over 40 μ), polygonal in shape and with several cytoplasmic processes (Fig. 1A) account on the average for 34.7% of the total number of cells counted, cells varying from 20 to 10 μ account for 53.7%, and the smallest, round cells, measuring about 10 μ, account for 11.6% of the total. Characteristically the large cells are unevenly distributed in the nucleus and concentrated in small groups. This was seen particularly clearly when they were drawn in a strip the length of one field of vision. If the column of cells counted is divided into zones each 500 μ in length, the number of large cells in the peripheral zone near the ventral border is 22.76%. In the central zone, in the same unit of the order of 500 μ, the large cells account for 38.86% of the total number of neurons in this zone. In the

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dorsal part of the nucleus the number of large cells is about the same as in the middle zone. Counts show that a tendency for the number of large neurons to decrease toward the ventral periphery of the nucleus is statistically significant. In some preparations these differences are particularly great: the relative number of large cells in the ventral part decreases by 2.6 times compared with the middle zone. Characteristically the decrease in the total number of neurons near the ventral perimeter of the nucleus takes place less intensively, and sometimes cannot be observed at all. Cells of medium size are scattered throughout the nucleus more or less uniformly. In the ventral part of the nucleus long, narrow, spindle-shaped cells can be seen, oriented mainly along the long axis of the nucleus, and attaining a length of 40 μ.

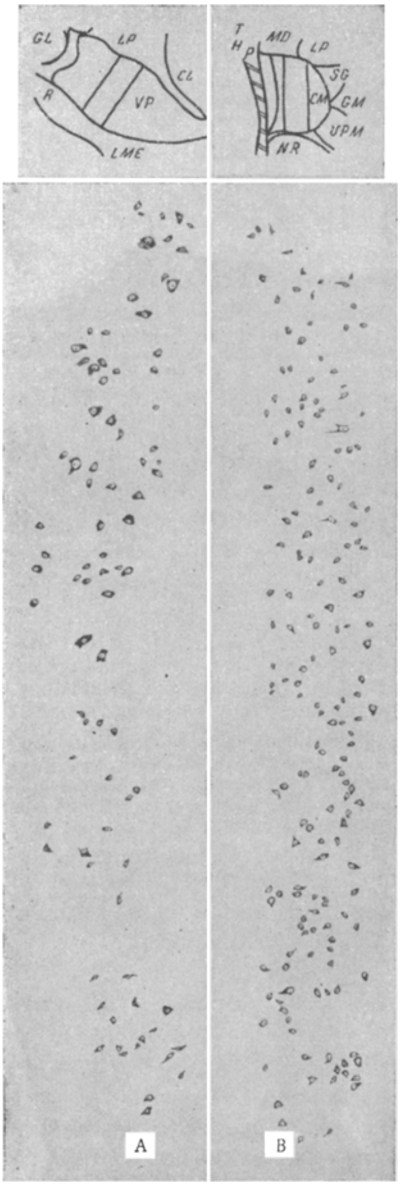

Fig. 1. Drawing of neurons from cat brain sections (10 μ) stained by Nissl's method in posterior ventral nucleus (A) and in centrum medianum (B). The parallel straight lines on the diagram denote the areas taken for investigation. RA-1 drawing apparatus; 400 ×. GL – lateral geniculate body; R – reticular nucleus; LME – external medullary lamina; VP – posterior ventral nucleus; LP – posterior lateral nucleus; CL – central lateral nucleus; THP – habenulo-peduncular tract; MD – medial dorsal nucleus; NR – red nucleus; CM – centrum medianum; SG – suprageniculate nucleus; GM – medial geniculate body; VPM – posteromedial ventral nucleus.

The neuron mat (Fig. 2) shows that VP is characterized by neurons with numerous winding dendrites, giving off numerous branches near the cell body (Golgi method). The neurons vary in shape: polygonal or circular with dendrites running in all directions; semilunar with dendrites precisely oriented; long and spindle-shaped (the processes of these neurons run mainly in two opposite directions, elongating their soma still more); trapezoid in shape, most of the dendrites emerging from the apex and a few from the lower corners of the trapezium, and so on. Cells lying very close to each other and intertwined by their dendrites may form complexes of neurons of distinctive shape: cell bodies lie in the center of the complex and their dendrites run toward the periphery to form a halo. According to some observations, these cells give rise to thalamocortical fibers [7]. Neurons with short axons and few branches are also found [2, 7, 9].

A different picture is observed in the nonspecific nucleus of the thalamus (CM). In contrast to VP (Fig. 1, B) this nucleus has indistinct boundaries. Most cells of CM are oval or circular in shape, although large cells with a few long cytoplasmic processes are seen. The nucleus of the neuron is round and surrounded by a small band of cytoplasm, palely stained and containing a little tigroid. Drawing the neurons in a frontal strip the width of 10 fields of vision in a dorsal-ventral direction of the section (Fig. 1, B) clearly reveals the uniform distribution of the neurons. In some sections a small increase in size of the cells can be seen at the medio-caudal border of the nucleus. Ramifications of dendrites of the CM neurons also differ essentially from those of the VP neurons: they have long, straight dendrites (Fig. 3); the number of cytoplasmic processes given off by a single neuron is much smaller. The dendrites themselves, as a rule, are thicker and appear as a continuation of the cell

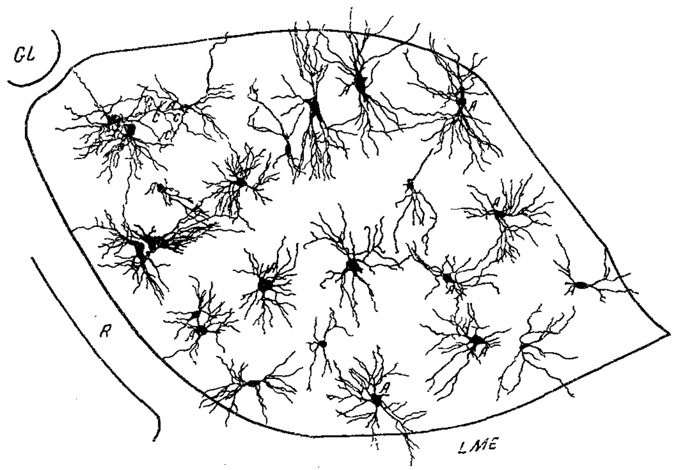

Fig. 2. Neurons of the posterior ventral nucleus. Golgi. RA-1 drawing apparatus; 400 ×. R – reticular nucleus of thalamus; GL – lateral geniculate body; LME – external medullary lamina; A – axon.

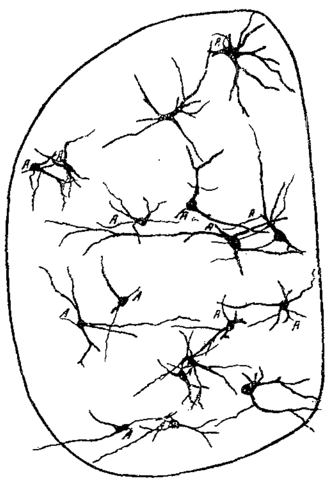

Fig. 3. Neurons of centrum medianum. Golgi's method. RA-1 drawing apparatus; 400 ×. A – axon.

body, so that it is often difficult to determine the point at which they leave the soma. Large cells, giving off dendrites extending almost the whole way across the nucleus, and small cells frequently located near the dendritic branches of large neurons, are dound in the CM.

As the example of the VP shows, a complex neuronal organization is characteristic of the specific nuclei of the thalamus. The relay nucleus consists of cells of different shapes and sizes, forming distinctive cell complexes. Short, branching dendrites constitute the structural basis of of somatotopic principle in the transmission of afferent impulses through the nucleus.

Conversely, in the nonspecific nucleus CM, long dendrites of the neuron, with few branches, bring about convergence of impulses from different parts of the nucleus on one neuron, and the grouping together of many such neurons into a complex may be responsible for the polysensory character of this nucleus by contrast with the monosensory character of the VP.

On the basis of structural differences between the specific and nonspecific nuclei of the thalamus it can be expected that investigation of single unit responses in VP and CM would reveal differences of function between types of neurons differing not only in modality (monomodal and polymodal), but also in the character of their response to afferent stimulation (relay, internuncial, and other types of cells). Corresponding data have already appeared in the neurophysiological literature [3].

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