

# THALAMO-CORTICAL PROJECTIONS TO TWO SOMATOSENSORY CORTICAL REGIONS

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UDC 611.812:611.814.7

It was shown by polarization and coagulation of various parts of the ventrobasal complex (VBC) of the cat's thalamus under acute experimental conditions that topographically separate regions projecting into somatosensory areas S1 and S2 exist in the thalamic relay nuclei. The anterior divisions of VBC send somatosensory projection fibers to S1 independently of projection fibers to S2. The caudal divisions of the nucleus project mainly to S2, and the central divisions of VBC to both S1 and S2.

Afferent projections in the somatosensory system at all levels of relaying to the cortex are known to be organized in accordance with the somatotopic principle [2]. This principle is clearly manifested at the thalamo-cortical level, where local areas of the somatosensory relay nucleus are connected to corresponding areas of the two somatosensory areas of the cortex [4, 6].

There is conflicting evidence in the literature regarding the localization of neuron groups in the thalamic nuclei projecting to somatosensory areas S1 and, in particular, S2. Some workers [7, 8] consider that the thalamic relay for S2 is the caudal part of the ventrobasal complex (VBC), while others regard it as the posterior thalamic group of nuclei, including the pulvinar (Pul), the lateral posterior (LP) nucleus, the magnocellular part of the medial geniculate body (GM), and the supragenicular nucleus (SG). Mountcastle considers that the VBC determines the somatotopic distribution in the first somatosensory area while the posterior group gives the cells of the second somatosensory area their modally nonspecific topographical properties [9].

It is only recently that experiments on rats have yielded results indicating that two separate regions of representation of somatic sensation exist in VBC, one linked mainly with S1 and the other with S2 [3]. It is assumed that these two regions of VBC are responsible for the conduction of afferent information to the corresponding cortical areas. With respect to other, more highly organized animals, notably cats, the classical object for neurophysiological and neuromorphological research and therefore of maximum interest, no such information is available.

The object of the present investigation was to determine the precise topography of thalamic regions of the cat brain projecting into the 1st and 2nd somatosensory areas.

## EXPERIMENTAL METHOD

Cats were anesthetized lightly with nembutal (20 mg/kg), immobilized with listhenon, and maintained on artificial respiration. The methods of local polarization or coagulation of the various parts of the VBC were used to study connections between the thalamic nuclei and the two cortical projection zones. Primary cortical responses in the areas of representation of the fore- and hind limbs in both somatosensory areas to stimulation of cutaneous nerves were recorded simultaneously. The nuclei were polarized by an electrode with a tip 50  $\mu$  in diameter for 30 sec. Under these circumstances, a decrease in amplitude of

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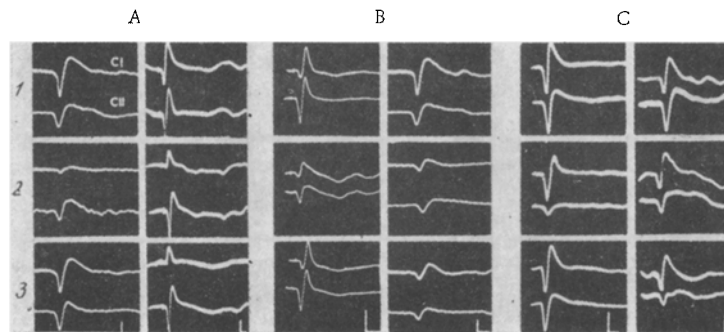


Fig. 1. Changes in primary focal potentials in somatosensory areas S1 and S2 of the cat cortex during polarization and coagulation of the anterior (A), middle (B), and posterior (C) portions of the ventrobasal complex. Top curve in C1, bottom curve in C2, and columns on the left obtained during polarization of VBC; columns on right during coagulation of VBC. 1) Before polarization and coagulation; 2) during polarization and coagulation; 3) after polarization and coagulation. Calibration: time 10 msec, amplitude 250  $\mu$ V.

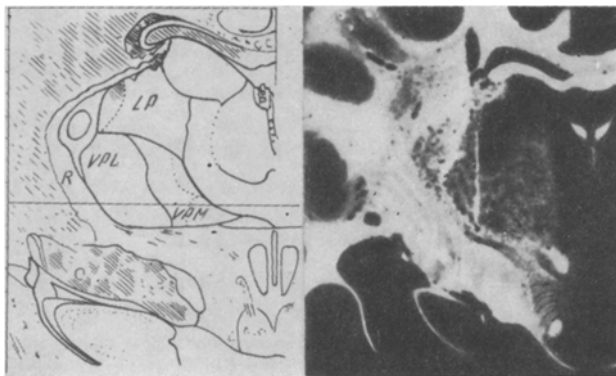


Fig. 2. Area of polarization in middle portion of ventrobasal complex of cat thalamus (moist unstained section). Frontal plane 9.0.

focal potentials evoked by afferent stimulation was observed in the corresponding parts of the cortical projection area. In other parts of the somatosensory cortex with no direct projection fibers from that particular part of the nucleus, the amplitude of the potentials was unchanged during polarization. The amplitude of the potentials recovered almost as soon as the polarization current was disconnected. The effect of a decrease in amplitude of the potentials could be observed repeatedly with repeated polarization. To obtain a permanent decrease in amplitude of the evoked potentials in the corresponding projection area of the cortex, the method of local coagulation was used. For this purpose, the strength of the current was increased to 2-3 mA for 40-50 sec. The use of these methods enabled a comparative analysis of the thalamic projections to the

two cortical somatosensory areas to be made. At the end of each experiment a histological examination was made of frontal sections through the nucleus to determine the position of the tip of the polarizing electrode.

## EXPERIMENTAL RESULTS

In the course of the experiments, the existence of topographically separate regions projecting into areas S1 and S2 was established. During polarization of the anterior parts of VBC (Fig. 1A), cortical evoked potentials in response to stimulation of a cutaneous nerve of the forelimb could be selectively blocked in somatosensory area S1. The response in somatosensory area S2 remained unchanged in this case. After disconnecting the current polarizing the nucleus, the evoked potentials in area S1 were completely restored. Coagulation of these same parts of the VBC led to almost complete inhibition of the response in S1 without subsequent recovery.

Polarization of the middle divisions of VBC (Fig. 1B) blocked the responses in both C1 and C2. On disconnecting the polarizing current, the responses in these cortical areas were restored. After coagulation of this part of the nucleus, the blocking of the evoked responses in the cortical areas was irreversible.

During polarization of the caudal divisions of VBC (Fig. 1C), responses were blocked only in S2 and remained in S1. After disconnecting the polarizing current the responses were completely restored.

Coagulation of these parts of VBC irreversibly blocked the responses in this area of the cortex without affecting the responses in area S1.

Histological examination precisely established the location of the polarizing electrodes (Fig. 2) in all three regions of VBC, so that a map of connections between the nucleus and the various parts of the somatosensory cortex could be drawn.

It can be concluded from these experiments that area S1 receives independent projection fibers from the anterior portions of VBC, independent from the projections of other parts of this nucleus in S2. The caudal divisions of the nucleus are projected mainly to S2, independently of the projections to S1. The middle divisions of VBC are evidently projected to both areas S1 and S2, although during polarization of these regions in about one-third of all cases the evoked responses were selectively blocked either in area S1 or in area S2. These results are also in agreement with those obtained by investigation of antidromic responses of VBC evoked by stimulation of the projection areas S1 and S2 [1].

The observations of Emmers and Rasmussen [3, 4], for example, made on rats, are thus confirmed in experiments on cats. The same principle can therefore be taken to underlie the projections of VBC in the cortex of all higher animals, including man.

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