INTERHEMISPHERIC TRANSMISSION OF VISUAL INFORMATION TO THE CAT SOMATOSENSORY CORTEX: ROLE OF SUBCORTICAL COMMISSURES

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KEY WORDS: interhemispheric transmission; visual information; somatosensory cortex; subcortical commissures.

The somatosensory cortex receives many visual afferent projections [1, 5, 8, 9]. Meanwhile the origin of visual inputs of the somatosensory cortex has received little study: Are they purely of the classical type (geniculate) or, as in the visual cortex, are they also commissural in origin [1, 2, 7]? The results of recent investigations point to the presence of a visual callosal input into the somatosensory cortex [6]. However, the role of other commissural structures of the end-brain in the conduction of visual impulses to the somatosensory cortex remains unexplained.

The aim of this investigation was to study the characteristics of interhemispheric conduction of visual information into this region of the cortex along diencephalic and mesencephalic commissural structures.

EXPERIMENTAL METHOD

Experiments were carried out on 16 cats divided into two groups: Group 1 consisted of intact animals (n = 8); group 2 consisted of cats with combined division of the left optic tract and commissures of the telencephalon, diencephalon (except commissural structures in the floor of the third ventricle), and mesencephalon (n = 8). Division of the cerebral commissures included the corpus callosum, anterior commissure, hippocampal commissure, fornix, septum, interthalamic commissure, intercollicular commissure, and posterior commissure. Division of the commissural connections in this way, together with division of the left optic tract, left only two theoretical possibilities of transmission of visual information into the hemisphere on the side of division: through commissural structures in the floor of the third ventricle and the mesencephalic reticular formation.

From 1 to 1.5 months after the neurosurgical operation nichrome electrodes (diameter of tip 5-10 μ) were implanted into symmetrical parts of the first somatosensory area at a depth of 1.0-1.2 mm. Experiments to record unit activity were carried out on unimmobilized waking animals, kept in a darkened chamber. A flash tube (energy 0.3 J, duration 0.2 msec) was the source of stimulation. Flashes were presented to the animals with a frequency of 0.5-1 Hz. Spike responses of somatosensory cortical neurons of animals of groups 1 and 2 also were recorded during the action of a conditioned visual stimulus (a white target). The cats were taught to strike the white target presented to them with the forelimb (animals undergoing operations were taught to strike the target with the right forelimb). Negative reinforcement consisted of electrodermal stimulation of the limb (square pulses, 30-60 V, 50 Hz, 1-2 msec). During an experiment the animals were allowed 20 attempts [3]. During the experiments the electromyogram of the working limb and the electrocorticogram (ECoG) also were recorded. To analyze the character of the spike discharges of somatosensory cortical neurons of animals of both groups to flashes and to the action of the conditioned stimulus, averaged histograms and histograms of interspike intervals were plotted by Élektronika 100-I computer for 25-50 realizations and the mean discharge frequency was determined. The significance of the results was analyzed by computer using the Kolmogorov—Smirnov λ^2 test and Student's test. Serial brain sections stained by Nissl's method were used for the morphological control.

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TABLE 1. Responses of Primary Somatosensory Cortical Neurons to Flashes and White Target in Intact and Commissurotomized Animals

Stimulus	Group of animals	Hemisphere	Total number of neurons	Number of neurons: with increased average discharge frequency	with reduced average discharge frequency	not responding to stimulation
Flashes	1 (control)	—	32	18 (56%)	6 (19%)	8 (25%)
	2	right	29	14 (48%)	5 (18%)	10 (34%)
		left	31	3 (10%)	10 (32%)	18 (58%)
White target	1 (control)	—	20	11 (55%)	2 (10%)	7 (35%)
	2	right	18	7 (39%)	3 (17%)	8 (44%)
		left	19	5 (26%)	6 (32%)	8 (42%)

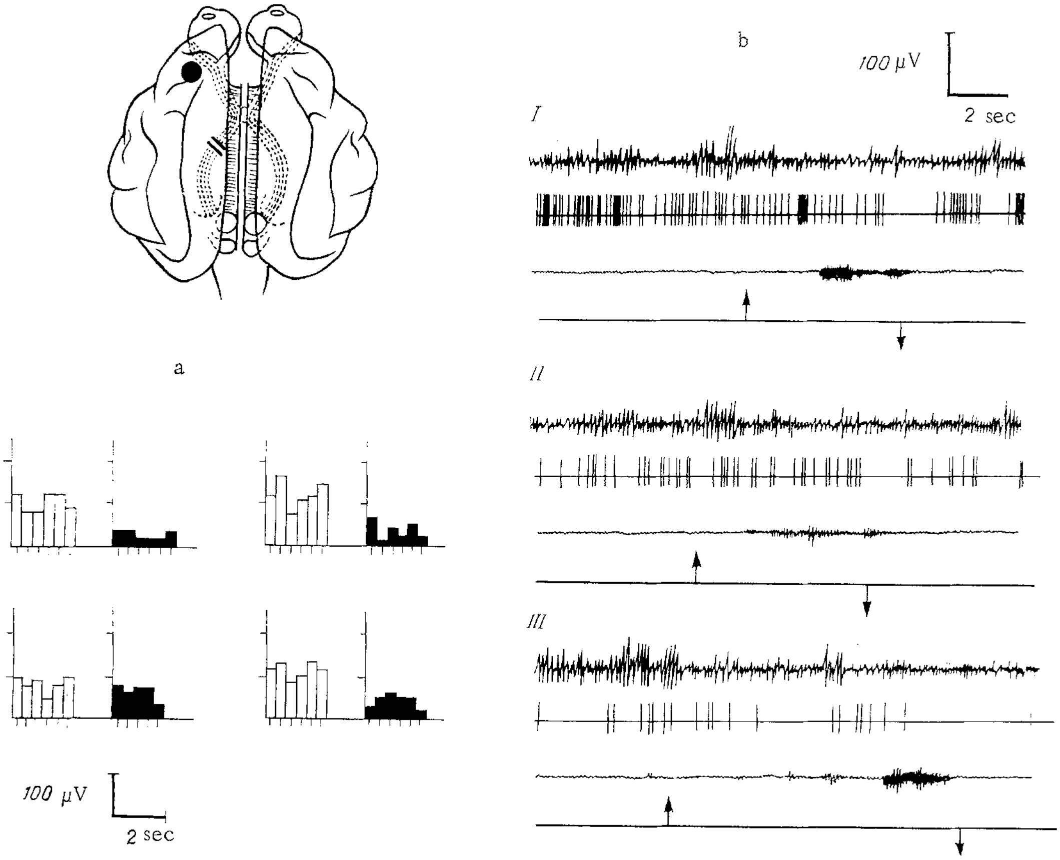

Fig. 1. Responses of left somatosensory cortical neurons in cats with combined division of left optic tract and cerebral commissures to visual stimuli. a) Responses to flashes: white and black columns denote pre- and poststimulus histograms respectively. Calibration: 10 spikes and 300 msec. b) ECoG, spike responses of neurons, and electromyogram of contralateral limb during three exposures of conditioned stimulus (white target). Arrows indicate beginning and end of exposure. Roman numerals — serial number of exposure.

EXPERIMENTAL RESULTS

The total number of neurons responding to visual stimuli was smaller in animals undergoing operation than in the control (Table 1). A decrease in the number of neurons responding to flashes was observed in the somatosensory cortex of both hemispheres, although this process was much less marked on the side of the divided optic tract (only 42% of neurons compared with 75% in the control). The character of responses of neurons in the visually "deafferented" somatosensory cortex also was changed. These neurons responded to flashes mainly by a tonic decrease in mean firing rate (Fig. 1a). In the contralateral hemisphere and also in the control animals, the opposite relationships were observed.

During the action of the conditioned visual stimulus (white target) the different responses of somatosensory cortical neurons of the intact and commissurotomized animals were much less marked than during the action of diffuse photic stimulation (Table 1). The percentage of neurons responding to exposure of the target in commissurotomized animals differed only a little from the control and was almost identical for both hemispheres. However, neurons of the left somatosensory cortex of the cats in group 2 responded much more frequently to exposure of the conditioned stimulus by a tonic decrease in the mean firing rate (Fig. 1b). The response of ECoG desynchronization to presentation of the conditioned stimulus was well marked in both control and commissurotomized animals (Fig. 1c).

Changes observed in the character of unit activity and the ECoG in response to the action of visual stimuli in the somatosensory cortex of the visually "deafferented" hemisphere of the animals of group 2 are evidence that commissural structures in the floor of the third ventricle and mesencephalic reticular formation are concerned in transhemispheric transmission of visual information into this projection region. The mainly inhibitory type of neuronal responses in the visually "deafferented" somatosensory cortex is evidently due to the greater relative contribution of commissural channels of the mesencephalic reticular formation. The ECoG desynchronization reaction is also evidently connected with these systems. Comparison of somatosensory cortical neuronal responses to the action of diffuse and conditioned visual stimuli in the animals of groups 1 and 2 demonstrates that the efficiency of transmission of visual information along diencephalic and mesencephalic commissural channels can be made more efficient if the biological importance of peripheral stimulation is enhanced.

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PHYSIOLOGICAL MECHANISM OF STABILIZATION OF THE PARTIAL OXYGEN PRESSURE IN CAPILLARY BLOOD

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KEY WORDS: fluctuations in partial oxygen pressure (pO_2) of arterial blood; pial microvessels; stabilization of pO_2 in capillary blood.

Establishment of the fact that oxygen diffuses through the wall of arterial microvessels introduced an essential correction into ideas on the principles governing oxygen transport from blood to tissue [2, 6, 7]. In particular, it was explained that under normoxemic conditions, with a decrease in diameter of arterioles, the partial oxygen pressure (pO_2) falls in blood flowing along them [3, 5, 7, 8]. As a result blood with its pO_2 considerably reduced compared with that in the aorta flows toward the capillaries. For instance, in the arterial portion of capillaries in the cerebral cortex it is 43 ± 3 mm Hg [5]. On this basis it has

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