COMMISSURAL CHANNELS TRANSMITTING VISUAL INFORMATION

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Previous investigations demonstrated the important role of the cerebral commissures in the conduction of sensory signals from a peripheral receptor to the cortical projection areas in mammals [1, 2, 7-10]. Visual information can be transmitted by telencephalic and mesencephalic commissures [1, 3, 5]. Results obtained by the writers recently also indicate the possible participation of diencephalic and reticular commissural structures in the transmission of visual information [4, 6].

The object of the present investigation was to compare the efficiency of commissural channels of the telencephalon, diencephalon, and mesencephalon in the transmission of visual information to the primary visual cortex, using evoked potentials (EP) and recording single unit activity.

EXPERIMENTAL METHOD

Experiments were carried out on 23 adult cats which were divided into three groups depending on neurosurgical operations performed on them: 1) control animals, 2) cats with division of the left optic tract and the left half of the tegmentum mesencephali; 3) animals with division of the left optic tract and telencephalic, diencephalic, and mesencephalic commissures. Division of the optic tract and half of the tegmentum mesencephali, including division of the brachium colliculi superioris, interrupted the geniculate and collicular visual inputs of the ipsilateral colliculus. Sagittal division of the cerebral commissures interrupted the following interhemispheric communications: corpus callosum, fornix, anterior cerebral, hippocampal, and interthalamic commissures, septum, and posterior and intercollicular commissures. In this case the left hemisphere of the animals of group 3 could receive visual information only via the commissures of the floor of the third ventricle and the commissural structures of the mesencephalic and medullary reticular formation. Nichrome electrodes in glass insulation (diameter of tip 5-10 μ) were implanted into symmetrical areas of the cortex of all the animals (1.5-2 months after the operation on those of groups 2 and 3). Investigations were conducted on waking animals, whose movements were partly restricted by the size of the experimental chamber. Photic stimulation consisted of flashes 0.2 msec in duration with a frequency of 0.5-1.0 Hz. EP and unit activity were led through UBP-1-02 biopotentials amplifiers and recorded on a four-channel magnetic recorder (Brüel and Kjaer), and then processed by Élektronika 100-I computer and recorded photographically. Analysis of unit activity by computer included calculation of integral pre- and poststimulus histograms for 25-50 realizations. The interval of analysis was 300-600 msec after stimulation. The significance of the results was subjected to statistical analysis by computer using the Kolmogorov–Smirnov λ^2 criterion (for single unit activity) and Student's test (for EP). At the end of the experiments the neurosurgical divisions were verified morphologically.

EXPERIMENTAL RESULTS

EP to flashes in symmetrical zones of the primary visual cortex in the cats of group 2 were 2-3 times less than in the control animals (Table 1). Asymmetry of EP amplitude also

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TABLE 1. Latent Periods and Combined Amplitudes of EP to Flashes in Visual Cortex of Both Hemispheres in Cats (M ± m; n = 50)

Group of animals	Hemisphere	Latent periods of separate first three components of EP, msec			Combined amplitudes, μV	
		first (−)	second (+)	third (−)	first + second	second + third
1 (control)	—	22,9±0,28	38,3±0,62	61,5±0,71	81,3±3,97	127,9±4,96
2	Right	23,9±0,23	47,3±0,80*	75,2±0,71*	36,8±1,20 †	49,8±1,62 †
	Left	22,5±0,68	39,4±1,15	67,6±2,24*	25,5±0,99 †	59,6±3,05 †
3	Right	22,7±0,74	42,0±1,14	82,1±2,7*	69,9±2,71 †	59,9±2,57 †

Legend. *P < 0.05; †P < 0.01.

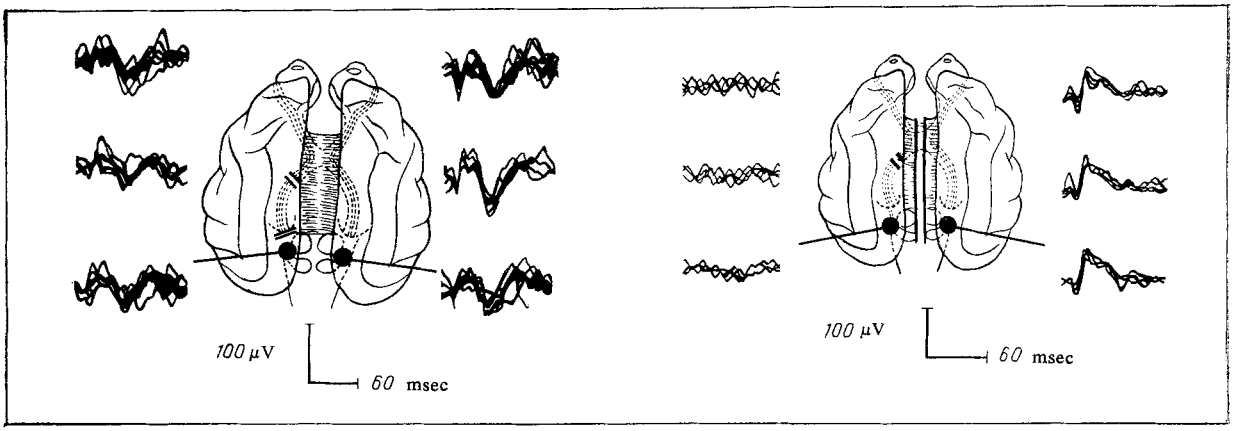

Fig. 1 Fig. 2

Fig. 1. EP to flashes at symmetrical points of primary visual cortex of animals of group 2. Left — EP recorded in ipsilateral visual cortex relative to division of optic tract; right — EP in visual cortex contralateral to divided optic tract.

Fig. 2. EP to flashes at symmetrical points of visual cortex of animals of group 3. Legend as to Fig. 1.

TABLE 2. Responses of Primary Visual Cortical Neurons in Both Hemispheres of Cats to Flashes

Group of animals	Hemisphere	Number of neurons recorded	Response latencies, msec			Tonic decrease in mean discharge frequency	Number of neurons not responding to stimulation
			0—50	50—150	150		
1 (control)	—	30 (100%)	14 (46%)	11 (37%)	2 (7%)	1 (3%)	2 (7%)
2	Right	25 (100%)	12 (48%)	3 (12%)	2 (8%)	1 (4%)	7 (28%)
	Left	31 (100%)	4 (13%)	6 (19%)	7 (23%)	3 (10%)	11 (35%)
3	Right	28 (100%)	9 (32%)	3 (11%)	5 (18%)	—	11 (39%)
	Left	32 (100%)	1 (3%)	4 (13%)	2 (6%)	8 (25%)	17 (53%)

was observed in the animals of this group (Fig. 1; Table 1). The combined amplitudes of the first and second components of EP in the right visual cortex of animals of group 2 were greater than in the left. The opposite relationship was observed for combined amplitudes of the second and third components. Latent periods of the third (negative) component were substantially longer in the animals of groups 2 and 3 than normally. In the left hemisphere of the animals of group 3 no EP to flashes could be recorded (Fig. 2).

Activity of 146 neurons was recorded in the animals of all three groups (Table 2). The percentage of neurons which responded to flashes was lower in the animals of groups 2 and 3 than in the control, regardless of hemisphere. The number of neurons with short (0-50 msec) and average (50-150 msec) response latencies also was reduced, especially in the hemisphere

on the side of the divided optic tract (Table 2); eight of the 15 neurons in the left visual cortex of the cats of group 3, which responded to flashes, reduced their mean discharge frequency tonically. Spike responses of neurons to flashes were recorded in this region despite the absence of evoked responses to the same stimulation.

These results are evidence of the important contribution of the forebrain commissures to visual information transmission into the cortical projection areas. The relative contributions of the various commissures of the telencephalon, diencephalon, and mesencephalon differ. Visual commissural channels of the telencephalon are the most strongly developed. Their activation in isolation (group 2) resulted in EP continuing to be recorded (Fig. 1a), and a high proportion of neurons still responded to stimulation by flashes. Interruption of these commissural systems, together with division of the optic tract, led to disappearance of EP in the ipsilateral visual cortex. However, visual information could still be transmitted. The main role in this process is played by commissural projections in the floor of the third ventricle and the mesencephalic reticular formation. The presence of neurons with short and average response latencies (Table 2) justifies the conclusion that modality-specific information can be conducted along these channels.

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