EXTRACALLOSAL CHANNELS FOR INTERHEMISHPERIC TRANSMISSION OF VISUAL INFORMATION

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There is much clinical and experimental evidence to show that the corpus callosum plays an important part in interhemispheric transmission of visual information [2, 4, 6, 10, 11]. The results of some investigations also suggest a possible role of extracallosal commissural pathways, especially the anterior [3] and collicular [1] commissures, in this process. Interhemispheric transmission of visual information can also evidently take place at the level of the brain-stem reticular formation and hypothalamus [5, 7, 9]. Nevertheless, these and other potential commissural pathways for conduction of visual information has not yet been identified by appropriate electrophysiological methods.

The aim of this investigation was to study the character of evoked electrical responses to flashes in different commissures of the forebrain and the brain-stem reticular formation in cats with varied degrees of reduction of their visual afferent pathways. By the use of these methods, together with neurosurgical divisions of the classical and commissural pathways, it was possible to demonstrate existence of parallel channels of interhemispheric transmission of visual information at all levels of the forebrain.

EXPERIMENTAL METHOD

Experiments were carried out on 14 adult cats divided into three groups: 1) control animals, 2) cats with division of the left optic tract, 3) cats with combined division of the left optic tract and commissures of the telencephalon, diencephalon, and mescencephalon. Division for the optic tract interrupted the classical visual commissural pathways into the ipsilateral hemisphere. Under these circumstances visual commissural inputs of the contralaterial hemisphere also were blocked. Additional interruption of commisures of the forebrain (corpus callosum, fornix, anterior interthalamic, intercollicular, and posterior commissures) in the animals of group 3 left two pathways of transmission of visual information into the "deafferented" hemisphere theoretically possible: the floor of the third ventricle and the brain-stem reticular formation. Nichrome electrodes (diameter 0.1-0.3 mm) were implanted into the posterior third of the corpus callosum, the floor of the third ventricle, and the region of the posterior cerebral commissure in accordance with stereotaxic coordinates [8] into animals of all the experimental groups (4-6 months after the operation into the cats of groups 2 and 3). The electrodes were implanted bilaterally into the reticular mesencephalic nucleus. The reference electrode consisted of nichrome wire (0.4 mm), taken in the form of a ring through the frontal sinus and occipital crest. Experiments were carried out on alert, unrestrained animals, to which flashes 0.2 msec in duration were applied binocularly with a frequency of 0.3-1.0 Hz. Electrical responses from the output of biopotential amplifiers were recorded on a magnetic tape recorder ("Bruel and Kjaer") and subsequently reproduced photographically and by averaging of evoked potentials (EP) by computer. EPs were averaged in groups of 40-50 within an interval of 200 msec with a discretization step of 0.5 msec. After the end of the experiments the positions of the electrodes were verified in serial brain sections stained by Nissl's method.

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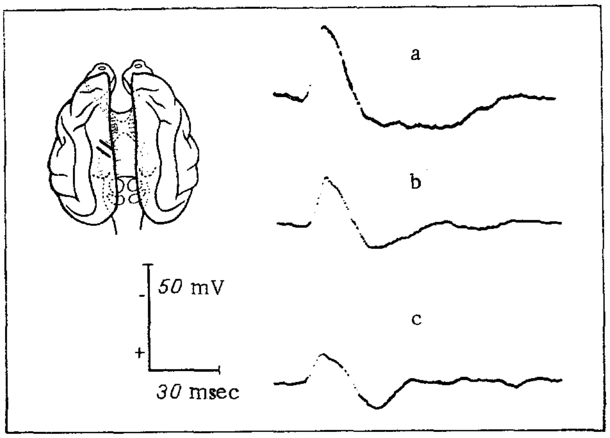

Fig. 1. Averaged EPs to flashes recorded in corpus callosum (a), floor of third ventricle (b), and region of posterior cerebral commissure (c) in cat with division of left optic tract (group 2).

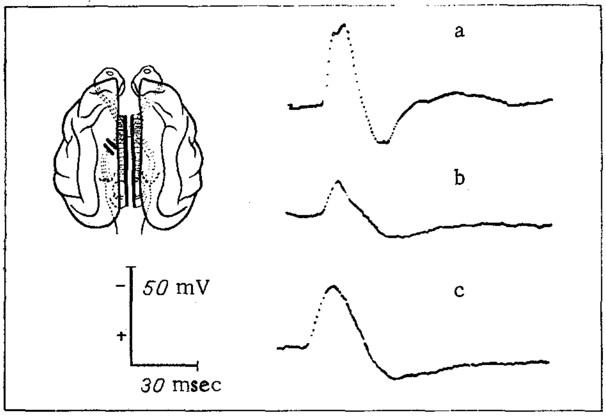

Fig. 2. Averaged EPs to flashes recorded in right (a) and left (b) mesencephalic reticular nuclei and floor of third ventricle (c) in cat with combined division of optic tract and forebrain commissures.

EXPERIMENTAL RESULTS

EP to flashes recorded in different brain commissures were similar in shape and had equal latent periods (Figs. 1 and 2). These EPs were mainly three-component positive-negative-positive complexes, the surface-negative component of which was much larger than the rest.

Interruption of the classical (retinal) visual pathways by division of the optic tract in animals of group 2 led to two opposite effects: a change in amplitudes of EPs to flashes recorded in the cerebral commissures and in symmetrically opposite zones of the reticular mesencephalic nuclei. In the first case a significant ($P < 0.05$) increase in amplitudes of the negative components of EP (corpus calosum and posterior commissure) was observed to 46.8 ± 4.1 and 25.6 ± 3.1 mV respectively from 34.0 ± 4.0 and 14.1 ± 3.1 mV in the animals of group 1; in the second case a decrease in amplitude of this same component of EPs recorded in the left mesencephalic nucleus and commissural structures in the floor of the third ventricle was observed (Fig. 1).

It may thus be tentatively suggested that the results show not only the leading role of callosal and mesencephalic interhemispheric communications in the transmission of visual information when retinal inputs into one hemisphere are blocked, but also the reciprocal character of reorganization of the whole commissural system.

Additional blocking of commissures of the telencephalon in the animals of group 2, leaving only two theoretically possible pathways for interhemispheric transmission of sensory information of visual modality (commissural structures in the floor of the third ventricle and brain stem reticular formation), did not lead to disappearance of EP in the reticular mescephalic nucleus on the side of the divided optic tract (Fig. 2).

A positive-negative-positive response complex, the characteristics of whose latent periods did not differ significantly ($P > 0.05$) from normal, was recorded in this structure, indicating that primary visual impulses can be transmitted across the midline along residual commissural pathways. Meanwhile a significant ($P < 0.05$) increase in amplitude of the negative component of EP in commissures of the floor of the third ventricle and in the right mesencephalic nucleus to 67.4 ± 4.9 and 62.1 ± 4.2 mV respectively evidently indicates an increase in the functional efficiency of these pathways for the transmission of visual impulses across the midline under conditions of maximal deficiency of interhemispheric connections. The considerable ($P < 0.05$) increase in latent period of the second positive component of the EP recorded from the floor of the third ventricle in the animals of group 3 also pointed to an increase in functional efficiency of this interhemispheric communication on account of an increase in power of the afferent flow.

Comparison of the results of this investigation with data obtained previously on the cat visual cortex [2, 4, 9] shows the similarity of the latent period of individual components of EPs to flashes recorded in different cerebral commissures and cortical visual centers. It may accordingly be concluded that synchronized conduction of visual impulses along callosal and extracallosal pathways of interhemispheric communication enables visual information to be transmitted to cortical centers at both the neocortical and the brain-stem levels.

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