FUNCTIONAL ORGANIZATION OF KINESTHETIC PROJECTIONS IN THE PRIMARY SOMATOSENSORY CORTEX OF CATS

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KEY WORDS: kinesthetic evoked potentials; somatosensory evoked potentials; kinesthetic projections.

The central-peripheral organization of the kinesthetic system, the principal system for sensory control of motor activity, has not yet been adequately studied. In the comparatively few papers published on this problem [3-5] there is no information on the character or conduction velocity of afferent impulses of kinesthetic modality from peripheral receptors to projection areas of the cortex in higher mammals and man. The widespread use of methods involving electrical stimulation of peripheral parts of the somatosensory system in order to study the functional organization of its brain centers does not allow kinesthetic influences to be differentiated sufficiently strictly from sensory signals of other modalities (nociceptive, tactile, temperature), for different receptors and mixed nerve conductors are involved. The search for effective ways of studying the central-peripheral organization of the kinesthetic system, just like the other subdivisions of the somatosensory system, thus requires the development of new approach techniques and new research tools, free from the drawbacks of the electrical stimulation method described above.

Accordingly the aim of the present investigation was to study amplitude-temporal parameters of central conduction of afferent impulses in response to specific kinesthetic stimulation by the method suggested by the writers previously [2].

The use of a method of nonelectrical stimulation of kinesthetic receptors parallel with recording of evoked electrical activity in the primary somatosensory cortex of cats has revealed significant differences in the organization of kinesthetic projections from the contralateral forelimb, compared with results obtained by recording somatosensory potentials [1, 3, 5].

EXPERIMENTAL METHOD

Experiments were carried out on four adult cats in which evoked potentials (EP) from the site of representation of the forelimb in the primary somatosensory cortex were recorded under superficial pentobarbital anesthesia (30-36 mg/kg). Recording was bipolar and monopolar. For monopolar recording a reference electrode (nichrome wire 0.4 mm in diameter),

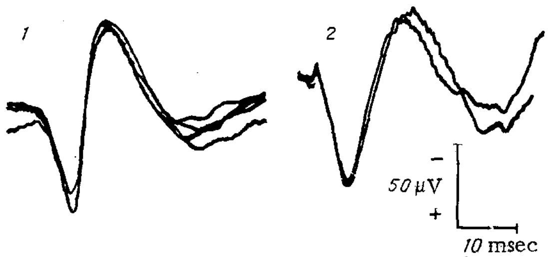

Fig. 1. SEP (1) and KEP (2) recorded in primary somatosensory cortex (superposition of 2-4 beams).

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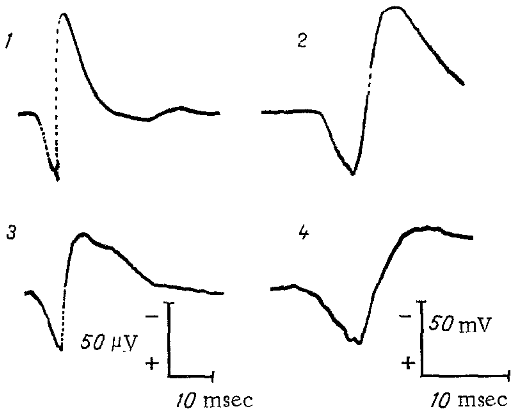

Fig. 2. Different time sweeps of averaged SEP (1, 2) and KEP (3, 4).

TABLE 1. Latent Periods and Amplitudes of EP to Electrical and Kinesthetic Stimulation of Contralateral Forelimb in Primary Somatosensory Cortex of Cats (M ± m; n = 100)

Type of stimulation	Latent periods of first three components of EP, msec				Amplitude of EP, μV		
	absolute latent period	first wave (positive)	second wave (negative)	third wave (positive)	first wave (positive)	second wave (negative)	third wave (positive)
Electrodermal	6,3±0,3	10,3±1,0	16,7±1,6	31,4±2,8	76,5±5,3	68,3±6,4	14,0±2,5
Kinesthetic	2,6±0,2*	8,0±0,9	18,3±2,1	44,0±3,2*	54,5±4,7*	48,7±3,2*	10,1±2,3

*P < 0.05.

which was passed through the bone tissue of the frontal sinus and occipital crest and joined into a ring, was used. In some cases, for control purposes the reference electrode was applied to the occipital muscles. The active electrode was a nichrome wire 0.1 mm in diameter, in glass insulation. Single electrodermal stimulation was applied to the anterior surface of the forearm through skin electrodes. The parameters of electrodermal stimulation were: square pulses 0.1-0.4 mA, 0.1-0.3 msec, 2-10 V. Kinesthetic stimulation was applied by means of a kinesthetic stimulator, a full description of which was given previously [2]. By means of this instrument passive extension of the cat's forelimb at the elbow was produced. The parameters of stimulation were: average angular velocity 500 deg/sec, duration 40 msec, amount of rotation 20°. EP were recorded photographically (superposition of two or three responses) and averaged by computer for 100 realizations. The discretization step was 0.01 msec and the epoch of analysis 20 and 50 msec. Statistical analysis of the significance of the results was undertaken by computer, using Student's test. Somatosensory and kinesthetic potentials were derived from the same point of the cortex of the same animal during stimulation of the contralateral forelimb.

EXPERIMENTAL RESULTS

Superposition of somatosensory and kinesthetic EP (SEP and KEP respectively) is illustrated in Fig. 1. Averaged EP are shown in Fig. 2; their latent periods and amplitudes are given in Table 1. The results show that KEP and SEP in the primary somatosensory cortex in response to stimulation of the contralateral limb were similar in shape and some of their latent periods and amplitudes were similar. Both sets of responses consisted of the same first waves: positive, negative, and positive. Sometimes in response to kinesthetic stimulation a small early surface-negative wave (Fig. 1) with a very short latent period (1.5-2 msec) was recorded. In most cases, however, the primary complex of KEP began with a positive wave. On the whole the first positive wave of KEP had a less steep rising phase than SEP, and its absolute latent period was significantly shorter (2.6 ± 0.2 msec compared with 6.3 ± 0.3 msec). The latent periods of the peaks of the first surface-positive waves of SEP and KEP did not differ significantly (P > 0.05). The rising phase of the second surface-negative wave also was less steep than that of SEP, although even in this case its peak latent periods did not differ significantly ($P > 0.05$). The descending phase of the second negative wave was much more gradual than that of SEP. The total duration of the three-component complex of KEP was 12 msec longer than that of SEP. The amplitude of KEP was significantly shorter than that of SEP ($P < 0.05$).

The results thus show that KEP in response to stimulation of the contralateral forelimb differ the most in the initial and final stages of development of the potential, whereas in the interval between the peak of the first positive to the peak of the second negative wave these differences were minimal, and in the last case this may reflect homogeneity of the afferent volley, arriving at that moment in the case of both kinesthetic and somatosensory stimulation. The shorter absolute latent period of KEP suggests a faster level of conduction of the modality-homogeneous afferent volley than in response to electrical stimulation, causing excitation of heteromodal receptors and mixed nerve fibers. A longer duration of KEP than of SEP can evidently be explained by the much longer time of peripheral stimulation, when kinesthetic influences continued to reach the projection cortex from the receptors for 40 msec.

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CORTICAL REPRESENTATION OF THE SINUS NODE OF THE HEART

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KEY WORDS: sinus node; afferentation; cerebral cortex

Much still remains unexplained in the problem of representation of the afferent systems of the heart at higher levels of the CNS. Most research on this theme either has been concentrated on the study of afferent impulsation arising in fibers of the vagus nerve in response to stimulation of the myocardial receptor apparatus of the atria and ventricles, the coronary vessels, and the pericardium, or has been limited to recorded evoked potentials (EP) in cerebral cortex and certain deep brain formations arising as a result of stimulation of cardiac branches of the same vagus nerve [1, 3, 4, 9, 10, 12-15]. The possibility that impulses may be conducted from receptor formations of the myocardium and pericardium to subcortical and cortical structures of the CNS by means of spinal afferent systems has received little study. Nevertheless, afferent systems have an "output" to tracts of the spinal cord via thick myelinated fibers and fibers of medium and small diameter, connecting the heart with spinal structures [2, 5, 7, 8, 11].

The aim of this investigation was to study the role of spinal pathways conducting afferent information, and to identify the distinguishing features of cortical representation of one of the most regularly important myocardial formations, the sinus nodal zone (SNZ).

METHOD

Acute experiments were carried out on 28 adult cats weighing 2.5-3.0 kg, anesthetized with chloralose (40-50 mg/kg) and curarized. Bipolar stimulating electrodes, insulated from surrounding tissues, were fixed in SNZ and to the ventricular myocardium. The heart was stimulated with square pulses (0.3 msec, 10-15 mA, frequency not more than 0.3 Hz) from an

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