CENTRAL AND PERIPHERAL ORGANIZATION OF THE KINESTHETIC SYSTEM STUDIED BY NATURAL STIMULATION OF PERIPHERAL RECEPTORS

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One of the most difficult problems in the study of functional organization of the kinesthetic system is the absence of sufficiently effective methods of adequate stimulation of peripheral receptors and of accurate evaluation of the parameters of intracentral conduction of modality-specific sensory influences. Most studies of central projections of someatosensory afferent pathways have been undertaken by the use of electrical stimulation [1-6]. When this type of stimulation is used, receptors of different modalities and mixed nerve fibers are involved, so that it is impossible to obtain a modality-specific afferent volley. In investigations in which natural stimulation of kinesthetic receptors was used [7, 9], parameters of afferent conduction were evaluated only approximately on the basis of changes in spike discharges of the neuron. Finally, although the recently developed method of kinesthetic stimulation [8] enables measured modality-specific stimulation to be carried out, because of artefacts it is impossible to determine the velocity of afferent conduction accurately in relation to early components of the evoked potential.

In the investigation described below, in the course of development of our own original method of natural stimulation of the kinesthetic system, we took into account the drawbacks mentioned above and created a special apparatus or kinesthetic stimulator (Fig. 1), by means of which a wide range of measured artefact-free stimulation of kinesthetic receptors could be carried out and the velocity of intracentral conduction measured accurately relative to early components of specific evoked potentials.

The kinesthetic stimulator consists of a moving platform, fixed on a horizontal axis, a combined electromechanical drive, a system of transducers (T_1 and T_2), and an electronic control unit (CU). The beginning and end of movement of the platform are recorded by the transducers T_1 and T_2. The active phase of movement of the platform is effected by the action of a spring, and to return the platform to its original position a cam fixed on the axle of the electric motor is provided. To fix the platform at the lower point of the angle of extension a stop buffer is provided, and its position can be used to vary the angle of deflection.

During an investigation using this stimulator the experimental animal (cats, rabbits, monkey, or dog) was placed in a stereotaxic apparatus. The platform of the kinesthetic stimulator was so placed that the axis of the elbow lay above its axis of rotation. The forearm of one limb was then fixed to the horizontal platform. On deflection of the platform by an assigned angle passive extension of the limb at the elbow took place, and synchronously with the beginning of movement of the platform, a marker for time counting was formed by the transducer T_1. By parallel recording of the EEG, an exact estimate could be obtained of the velocity of conduction of the afferent signal, based on the latent period of the evoked potential in response to natural kinesthetic stimulation. A comparative study of the character of evoked somatosensory (to electrical stimulation) and kinesthetic potentials recorded in the contralateral first somatosensory area in cats revealed considerable differences between their first surface-positive components. The latent periods of the first positive components of the kinesthetic potentials were 67-75% shorter than the somatosensory potentials, namely 1-2 msec

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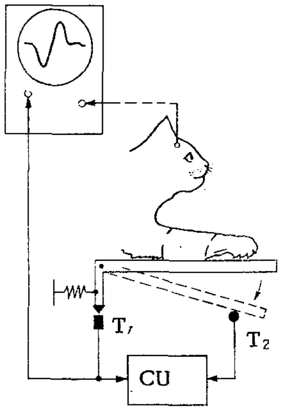

Fig. 1

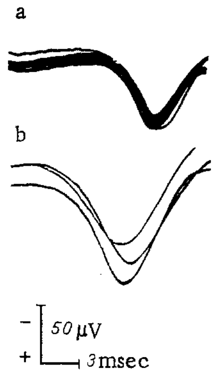

Fig. 2

Fig. 1. Block diagram showing principle of apparatus for kinesthetic stimulation. Explanation in text.

Fig. 2. Evoked potentials in contralateral somatosensory cortex of cats to electrodermal stimulation of forelimb (a) and kinesthetic potentials (b).

compared with 5-6 msec in response to electrical stimulation (Fig. 2). The kinesthetic potentials also were more locally represented in the cortex than somatosensory.

Preliminary results obtained with this method of kinesthetic stimulation developed by the writers indicate the need for revision of current ideas on the sensory system according to which kinesthetic signals may be transmitted without relaying in the brain stem. The significant differences in the latent periods of evoked potentials to electrical and natural stimulation evidently indicate interference between excitation of different modalities in the first case, masking the wave of kinesthetic excitation.

The method of natural stimulation of specific receptors can evidently be used as a new and effective way of studying the organization of the kinesthetic system under clinical as well as experimental conditions.

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