Cerebral Control of Afferent Somatosensory Projections

E. V. Petrenko, T. V. Orlova, and N. N. Lyubimov

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Recent research has revealed that somatosensory effects arising in the brainstem are controlled by brain structures [1], but these data were mainly obtained under artificial conditions on animals: in acute experiments, under narcosis or immobilization. Thus, further research of these phenomena was needed, with a differentiated assessment of descending cerebral effects for various stem and cerebrospinal targets. Furthermore, these data had to be applied to the human brain, and the corresponding changes in some components of responses induced by median nerve stimulation had to be followed up against the background of altered consciousness.

MATERIALS AND METHODS

Sixteen healthy volunteers of both sexes aged 34 to 54 who had been practicing the transcendental meditation technique for two years took part in the study. Somatosensory evoked potentials (SSEP) were recorded before and during meditation (5 min after its start). SSEP of the cerebral cortex and Goll's and Burdach's nuclei were recorded with applied electrodes in response to electrical stimulation of the median nerve at the wrist with rectangular pulses of 0.1 msec duration and an intensity corresponding to the motor response threshold in thumb eminence muscles (about 20 mA). The stimuli were delivered at random intervals once every 2-3 sec. During the recording of cortical SSEP, active electrodes were placed at points C'3 and C'4, 2 cm behind points C3 and C4 according to the "10-20 system" [4], and indifferent electrodes were placed 6 cm in front of the active ones. In the recording of evoked potentials from Goll's and Burdach's nuclei an active electrode was placed above the spiny process of the second cervical vertebra and an indifferent electrode on the shoulder contralateral to the stimulated hand. SSEP were recorded with a Nihon Kohden system (Japan), including an AVH-10 biopotential amplifier, DAT-1100 computer, VC-10 oscilloscope, RLG-6201 photorecorder, and SEN-7103 electrostimulator. The data were statistically processed using the Student t test.

RESULTS

Negative oscillation N13 with an average amplitude of 2 μV could be clearly discerned within the SSEP of the spinal dorsal column nuclei recorded before meditation. The positive complex which ensued consisted of two positive oscillations with latencies of 19 and 28 msec, separated by a negligible wave not reaching the isoline with a latency of 21 msec. The mean amplitude of this positive complex was 3 μV. Then followed N58 with an amplitude of about 5.1 μV.

An N19 component with an amplitude of about 1.6 μV was persistently distinguished within the cortical SSEP of the hemisphere contralateral to the stimulated median nerve. The positive complex which followed it consisted in different ex-

Brain Research Institute, Russian Academy of Medical Sciences, Moscow. (Presented by O. S. Adrianov, Member of the Russian Academy of Medical Sciences)

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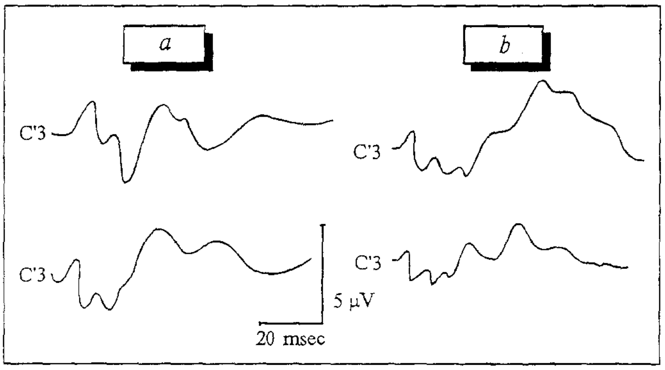

Fig. 1. Averaged somatosensory evoked potentials of the contralateral hemispheric cortex in response to electrodermal stimulation of the right median nerve in 4 examinees. *a*) positive complex splitting into components; *b*) positive complex splitting into 3 components.

aminees of two positive components with latencies of 25 and 41 msec, separated by an oscillation not reaching the isoline with a latency of 31 msec (Fig. 1, *a*) (in 9 subjects), or of 3 positive components with latencies of 24, 35, and 48 msec, separated by oscillations not reaching the isoline with latencies of 28 and 42 msec (Fig. 1, *b*) (in 7 subjects). The mean positive complex amplitude was 4.1 μV. The N77 component of 5 μV amplitude was also stably recorded.

Comparison of the cortical and dorsal column nuclear SSEP recorded during transcendental meditation (5 min after its start) and the background recording showed no changes of the latencies of the early components, but their amplitudes were found to be increased by 1.6-1.7 times on average (Fig. 2, *a*, *b*). It should be mentioned, however, that these changes were not equally pronounced in all the examinees: the increase of amplitudes was negligible in some subjects.

The statistically processed values of the amplitude of the early components of the cortical and dorsal column nuclei SSEP are presented in Table 1.

As we previously revealed in experimental animals, dissection of the half of the midbrain tectum which includes the descending inhibitory pathways to various structures of the brainstem and spinal cord leads to an increase of the amplitude and time characteristics of the first (N) and second (P) components of evoked potentials in the spinal dorsal column nuclei in response to stimulation of the respective forelimb in a chronic experiment [1]. We believe these results may be explained by activation of various inhibitory elements in these structures located near respective relay cells of the lemniscus system.

In our view, these findings are indicative of at least two effects which are different from the standpoint of the end target. One of these effects activates inhibitory neurons of the spinal terminal of Goll's and Burdach's nuclei relay (lemniscus) cells, this leading to an increase of the P component of these structures' evoked response resulting from a prolongation of presynaptic inhibition corresponding to depolarization of these terminals. Other effects reaching these formations in parallel with the former effects activate the inhibitory neuron, which in turn controls the inhibitory neuron directly organizing postsynaptic inhibition of the relay cell. The upshot of all this is "inhibited inhibition" - weakening of postsynaptic inhibition, which leads to an increase of the first component of the response in Goll's and Burdach's nuclei evoked by forelimb stimulation.

Studies of neuronal mechanisms of transcendental meditation [5] showed that this state is as-

TABLE 1. Amplitude of Early Components of Somatosensory Evoked Potentials before and during Meditation ($M \pm m$)

Component	Background	Transcendental meditation
	Dorsal spinal nuclei	
N13	2.14±0.25	3.84±0.38*
P19−28	2.98±0.3	5.1±0.4*
N58	5.13±0.36	8.56±0.57*
	Cortex	
N19	1.62±0.17	2.73±0.31*
P25−41		
P24−35−48	4.06±0.35	6.59±0.49*
N77	5.0±0.36	8.08±0.48*

Note. The asterisk denotes reliable ($p<0.01$) values.

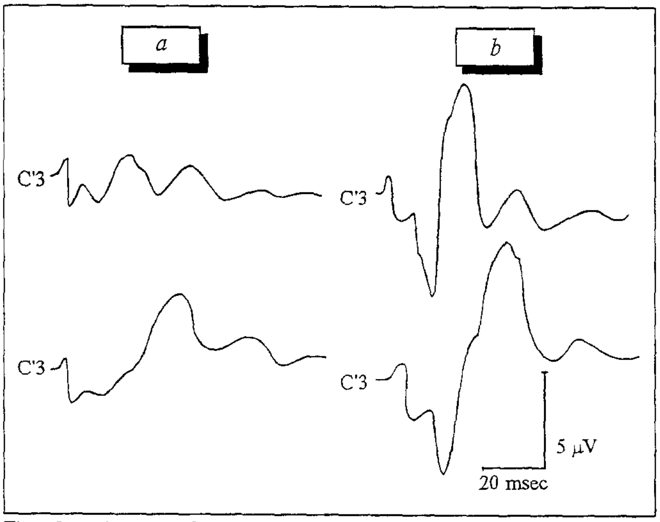

Fig. 2. Averaged somatosensory evoked potentials of the contralateral hemisphere (C'3) and dorsal column nuclei (C2) in response to electrodermal stimulation of the median nerve before and during meditation. *a*) background; *b*) 5 min after start of meditation.

sociated with the formation of contrasting functional shifts in the forebrain and spinal structures. The spectral power of electrical activity in the θ- and α-bands is increased in the forebrain parietal and somatosensory structures, this corresponding to increased excitability of these structures. Moreover, the topology of a number of early components of somatosensory evoked responses is extended [2,3]. This is paralleled by a muscle tone weakening resulting from enhanced inhibitory effects issuing from the motor cortex and caudate nucleus structures in the direction of the spinal inhibitory mechanisms. We observed increased amplitude of the early SSEP components in the cortex and dorsal column nuclei during transcendental meditation. Analysis of our findings and published data suggests that transcendental meditation is associated with a functional mobilization of the total spectrum of cerebral descending coordinating effects directed to the posterior portions of the brainstem and spinal cord. These effects differ for various afferent and motor structures of the brain. The highly selective activation of various inhibitory elements in the dorsal column nuclei, coupled with the changed balance between pre- and postsynaptic inhibition of spinal dorsal column relay elements, leads to a broadening of the topology of just a number of SSEP in the cortex (N21, P40, N59) [3]. This highly differentiated process results in activation of the structures (mainly in the parietal and frontal areas of the cortex) which to a greater extent contribute to intellectual activity. As for the spinal structures, inhibitory element activation during transcendental meditation is associated here with motoneuron inhibition and muscle tone weakening.

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