RESULTS OF MULTICHANNEL RADIOELECTRO-ENCEPHALOGRAPHIC INVESTIGATION OF PERSONS WITH NERVOUS AND EMOTIONAL STRESS

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In the EEG of students during examinations the slow high-amplitude rhythm is increased, mainly in the occipital regions.

Investigations [5-7] have shown that mental activity produces generalized depression of slow activity on the EEG. At the same time, unfavorable environmental factors are known to contribute toward the appearance of a high-amplitude slow rhythm on the EEG [2,3].

The object of the investigation described below is to analyze changes in electrical activity of the human brain during intensive mental activity when the subjects were in a state of stress.

EXPERIMENTAL METHOD

A four-channel bioradiotelemetric system (4BÉP-1) and a corresponding two-channel system (2BÉP-2) were used for the investigation. The apparatus and method were designed and developed by the Sverdlovsk Bioradiotelemetric Group under the direction of Professor V. V. Rozenblat. The transmitter, weighing 590 g (4BÉP-1) or 260 g (2BÉP-2) was fixed in the pockets or on the belt under the outer clothing worn by the subject (students during examinations). The frequency characteristic of the system at the 3 dB level is 0.5-100 pulses, amplitude distortions with an interelectrode resistance of 10 kΩ do not exceed 5%, the double noise amplitude is not more than 5 μV, the dynamic range 5-200 μV, and suppression of cophasal interference is not less than 100 times. The instruments have quartz frequency stabilization and operate in the ultrashort waveband. The distance through which information can be transmitted is not less than 100 m (4BÉP-1 system) and 25 m (2BÉP-2 system). The radioreceiver with decoder and recorder (4ÉÉG-1 electroencephalograph) were kept in the experimental laboratory, which was next to the examination hall. Cuff-shaped electrodes made of pure tin were fixed to the subject's head by means of a system of rubber bands and an elastic chin strap. Hair under the electrodes was displaced to the side, and the skin was treated with a mixture of alcohol and ether in the proportion 1:1. Brain potentials were recorded from the sensorimotor and occipital regions of both hemispheres with the zero electrode placed in the region of the vertex (the vertical lead [4]). Information was recorded repeatedly in the course of one observation with the eyes open and closed: before the examination, while preparing to answer—at the second, 10th, 15th, 20th, 40th, and 50th minutes, during the oral examination, and twice after the examination. Altogether 10 students from the first and second courses of the Institute of National Economy took part in the investigation: seven women and three men aged from 18 to 37 years. None of the subjects had any nervous or physical disorders. The observations were carried out during examinations in work physiology, history of the CPSU, and higher mathematics. With the exception of one subject, who received an unsatisfactory mark, the remainder answered well.

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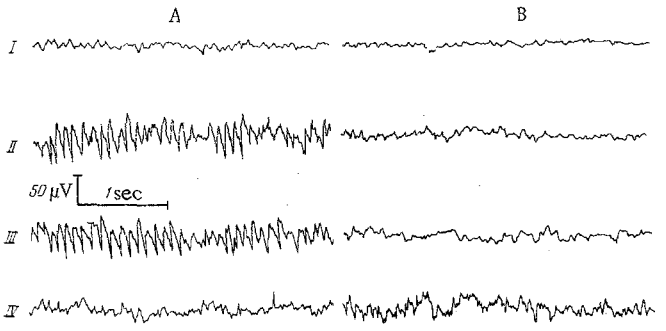

Fig. 1. Radioelectroencephalogram (REEG) of student N., aged 19 years, while preparing to answer in an examination with the eyes open: A) at the 15th minute; B) 50th minute; I) left sensorimotor lead; II) left occipital; III) right occipital; IV) right sensorimotor lead.

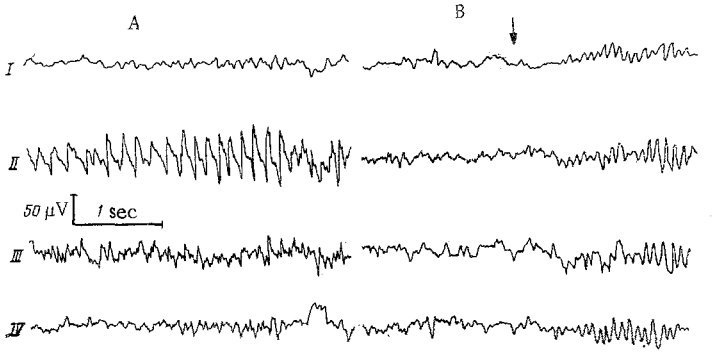

Fig. 2. REEG of student N., aged 19 years, at 20th minute of preparing to answer with eyes opened (A) and 1.5 min after receiving examination paper (B). Arrow indicates time of closing eyes. Leads as in Fig. 1.

EXPERIMENTAL RESULTS

From the time that the student received his examination ticket and began to prepare his answer, in most cases the pattern of brain electrical activity showed sharp changes. Despite the beginning of intensive mental work, instead of a depression of slow activity it was increased. With the subject's eyes open, while thinking over his answer and making various notes, drawing graphs and diagrams, the EEG was dominated by slow high-amplitude waves in the occipital regions of one or both hemispheres (Fig. 1A). This activity was also found in the sensorimotor areas only in one case, and even then it was much more marked in the occipital leads. This rhythm, which was very regular, could persist for a long time and reached an amplitude of 60-90 μV and a frequency of 11-13/sec. Periodically, at various intervals, it was replaced by a rhythm of lower amplitude and frequency, or was extinguished, and changed into a low-amplitude activity (Fig. 1B). Desynchronization of this type was observed most frequently in the middle or at the end of the period of preparing the answer, when the subject was tranquil. The beginning of the answer again caused the appearance of high-amplitude slow activity in the same leads, frequently with pointing of the waves. Sometimes instead of this rhythm, grouped paroxysmal discharges of high-amplitude α- and Δ-, less frequently of Θ-rhythms were observed (Fig. 2A). Throughout the period of preparation and during the answer, if the eyes were momentarily closed, α-activity of varied intensity was recorded in all leads. The amplitude of the waves often was the same whether the eyes were open or closed. A similar regular rhythm with frequency of 5-7/sec, and with a definite and constant distribution over the cortical areas (the stress-rhythm) is also found in animals. It is regarded as a reliable electroencephalographic sign of negative emotional excitation [2].

Students are evidently profoundly agitated during examinations, with anxiety in the face of an unfamiliar question and doubts about the correctness of the answer; all these cause the periodic appearance of

TABLE 1. Mean Values of C/O in Different Parts of the Brain for Three Students during Examinations

Time of measurement	Left hemisphere		Right hemisphere	
	region			
	sensori-motor	occipital	sensori-motor	occipital
Before examination	5.1	1.7	4.2	1.3
While preparing to answer	6.1	5.1	4.7	5.0
After examination	3.2	2.8	3.8	1.4

the rhythm described above. The presence of this activity cannot be regarded as due to predominance of inhibition in these parts of the cortex. If the C/O ratio (the ratio between the latent period of the response to closing and opening of the eyes), which reflects the relationship between excitation and inhibition [1], was used for guidance, in all the cases observed it never fell below 1. According to data in the literature [1,4], cases with C/O greater than 1 correspond to a relatively high state of brain function. Changes in C/O at different times of examination are given in Table 1, as mean values for three subjects on the basis of 86 measurements.

In the first few minutes after distribution of the examination papers, in all cases the pattern of brain electrical activity was sharply modified, and it corresponded largely to its state before the examination (Fig. 2B). Three cases, when throughout the period of the examination signs of desynchronization were predominant and slow high-amplitude activity was hardly observed at all, deserve special mention. These subjects were tranquil throughout the examination.

It can thus be concluded that the whole of the conditioned-reflex behavior during a state of stress such as occurs during examinations corresponds to a definite EEG syndrome, consisting mainly of an increase in high-amplitude, periodically regular or paroxysmal slow activity, with the eyes open, especially in the occipital regions. The vital role of nervous and emotional stress is shown by the fact that in none of the earlier observations made on students during lectures were such changes in the brain rhythm observed.

The appearance of a slow rhythm is interpreted as a sign of increased activity of cortical and subcortical elements, and not of predominance of inhibitory processes.

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