CHANGES IN THE ELECTRICAL ACTIVITY OF THE HUMAN BRAIN DURING THE INITIAL PERIOD OF MUSCULAR ACTIVITY

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The number of investigations dealing with the electric activity of the brain during muscular activity is very limited owing to practical difficulties. There has been no special study of changes in electrical activity of the brain during the initial period of work, although some authors have noted that the beginning of muscular activity was accompanied by the appearance of fast activity in the electroencephalogram of the same type as muscle potentials [5] or by depression of the α-rhythm [4].

The aim of the present work was the systematic study of changes in the electrical activity of the brain during the initial period of muscular activity.

EXPERIMENTAL METHOD

The electroencephalogram was recorded during the performance of work by the method described earlier [2]. Reliable contact between the electrode and the scalp was achieved by careful application of stick-on electrodes to the muscle-free parts of the scalp; paste and additional "bracing" of the leads were employed. Standard positions of the electrodes were determined experimentally.

The electrical activity of the brain was recorded by means of a 4-channel ink-writing electroencephalograph (made at the AMN SSSR experimental plant). Bipolar recording was usually used. The movements investigated in this work were familiar and habitual for the subject: work on bicycle-ergometer of moderate power (15-50 revolutions of the pedals per minute), various types of rhythmic hand movements with different loads, static muscle exertions (trunk, arms, legs). A total of 80 experiments were carried out on 7 subjects. At rest all the subjects showed an α-rhythm and the response to eye opening and eye closure was of the usual kind.

EXPERIMENTAL RESULTS

The beginning of muscular activity gave rise to depression of the α-rhythm in the electroencephalogram during which most of the subjects showed activity of the β-rhythm type. As the work proceeded small groups of α-waves, alternating with periods of α-rhythm depression, began to appear against this background. The frequency of the α-rhythm increased by 1-2 cps as compared with its frequency at rest; the amplitude was decreased. Sometimes some of the temporal leads showed slower activity at a frequency of 3-4 cps. Later, the bursts of α-rhythm became more definite and prolonged, while periods of its depression diminished in duration. The frequency of the α-rhythm itself decreased and the amplitude increased until the two returned to the values observed at rest. In some cases it was possible to discover a definite periodicity in the appearance of the bursts of α-waves, coinciding with the rhythm of the movement.

Further continuation of work was accompanied by α-rhythm which was not significantly different from α-rhythm at rest.

The time which elapsed from the beginning of work until the appearance of α-rhythm with frequency and amplitude characteristic for the resting state was taken as the duration of the initial period of work. Figure 1 shows the initial period of muscular activity upon flexion and extension of the arm on an ergograph with a load of 1.5 kg. The beginning of the familiar muscular activity was accompanied by depression of the α-rhythm and the appearance of fast activity of β-rhythm type in the encephalogram; as the work continued, the fast activity was gradually replaced by α-rhythm.

In this experiment muscle potentials were recorded from the active muscles simultaneously with the EEG. The electromyogram shows that as work continues the duration of the bursts of muscle potentials decreases and becomes stabilized, which denotes gradual perfection of the movements performed as compared with the initial period [1].

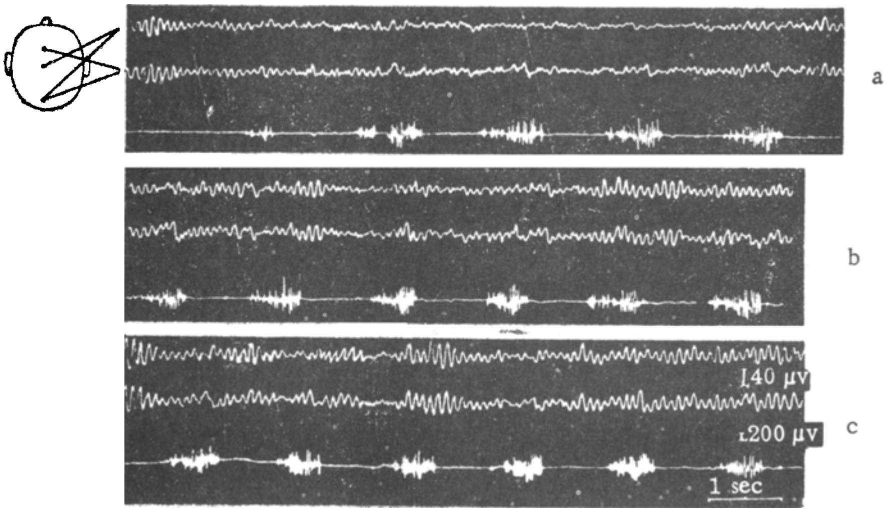

Fig. 1. Changes in the electrical activity of the brain in subject G. during performance of work. During the initial moment of muscular activity the EEG shows depression of the α-rhythm. On continuation of work there is restoration of the α-rhythm to its resting characteristics. Sections a, b, c are a continuous record of the same EEG, c) recorded 1 min 30 sec after the beginning of work. The lower trace in each section – electromyogram; bursts of muscle potentials correspond to the rhythm of the movement.

The EEG changes described above as characterizing the beginning of work were not always sufficiently clear. The degree of change of the EEG components and the duration of the initial period of work could show considerable fluctuations. Even in one and the same experiment the changes in electrical activity of the brain during the beginning of work were not constant but depended on the character and power of the work performed earlier and subsequently in that particular experiment.

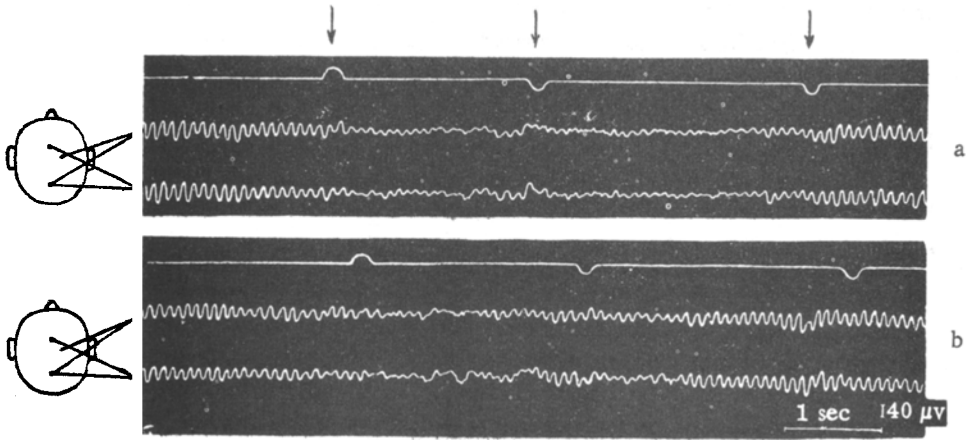

Fig. 2. Changes in the electrical activity of the brain in subject K-o on repeating the work. Diminution of the initial period is noted. a) First performance of the work; b) repeat of performance of the work; ↓ – signal denoting beginning of movement; upper tracing – recording of the rhythm of movement.

Repeating work of the same type and degree reduced the initial period of the work. This was observed on repeating the same type of muscular activity from one experimental day to another and even more so on repeating the work after short intervals of time (2-5 min). Figure 2 shows that a repetition (after 2 min) of rhythmic movements — elevation and lowering of the arm with a load — is accompanied by smaller changes in the EEG and a shorter initial period of work which diminished from 5 sec during the first performance of the work to 3 sec when it was repeated.

Preparatory work, carried out with greater effort (higher frequency of movement) decreased the initial period of subsequent work. When the preparatory work was different in coordination pattern from the subsequent work the initial period was longer and the EEG changes greater than in cases in which the preparatory work was similar in nature.

For example, after work consisting of the same movements (rhythmic elevation and lowering of the arm) the initial period was equal to 6 sec. After complex (from the point of view of coordination) exercises performed simultaneously by the left arm and leg, the initial period of subsequent rhythmic movements of the arm increased to 9 sec and the depression of the α-rhythm was more profound and prolonged.

By specially selecting the exercises for preparatory and subsequent work, varying their frequency, number of repetitions, etc., it is possible to achieve diminution of the initial period of work and even its disappearance. In the latter case the EEG will show, from the very beginning of muscular activity, a stable α-rhythm, as shown in Fig. 3.

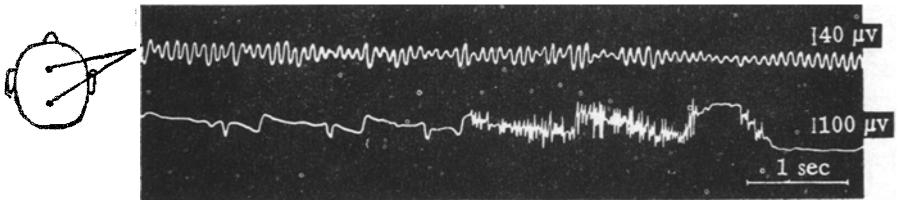

Fig. 3. Absence of changes in the electrical activity of the brain in the subject K-o during the beginning of work. Records (from above down): electroencophalogram, biceps electromyogram on elevation of the load.

The adaptation of the organism to new conditions is associated with certain "tension" — certain adjustment. "Time is required to achieve a new adjustment" wrote I. P. Pavlov [3].

The process is reflected also in the electrical activity of the brain: at the beginning of work there is depression of the α-rhythm with the appearance of β-rhythm-type of activity which becomes replaced by groups of faster α-waves as the work continues; the EEG then shows a stable α-rhythm with frequency and amplitude similar to those observed in the resting state. Evidently this reflects the interrelations of the main nervous processes in the cortex of the cerebral hemispheres. It may be postulated that during the beginning of work there is a change in the balance of the main nervous processes towards predominance of excitation in certain groups of cortical cells which probably finds reflection in depression of the α-rhythm and the appearance of the β-rhythm type of activity. Further repetition of the same movements apparently requires less "tension" of the excitatory process as shown by the constant restoration of the α-rhythm with decrease in its frequency and increase in its amplitude and the appearance of waves slower than the α-rhythm. The periodic appearance and disappearance of groups of α-waves evidently denotes the existence of "uninterrupted struggle between excitation and inhibition" (I. P. Pavlov).

As the movements become completely automatic an α-rhythm indistinguishable from the resting α-rhythm is recorded.

The initial period of muscular activity is very reactive: the depth of changes in the EEG and the duration of this period may alter significantly (up to complete disappearance) depending on the number of repetitions of the same type of activity and on the type and degree of the preparatory work. Such sensitive reaction suggests that alteration of the type of muscular activity may hinder or facilitate the adjustment of the organism to the work it is to be required to perform.

SUMMARY

Initial muscular activity is associated with depression of the α-rhythm and appearance of high-frequency oscillations of the β-rhythm type in the electroencephalogram. On continuation of the work, short periods of α-rhythm begin to appear on this backgroun and gradually increase. If the work is continued further it is accompanied by an α-rhythm which is almost no different from the α-rhythm in the state of rest. The duration of the initial period of work depends on the character and power of the preparatory and the subsequent work.

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ELECTROPHYSIOLOGIC INVESTIGATION OF THE MECHANISM OF CHEMORECEPTION

COMMUNICATION III. THE EFFECT OF NICOTINE AND ACIDS ON THE INTESTINAL RECEPTORS IN MONOIODOACETIC-ACID-INDUCED DISTURBANCES OF METABOLISM

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Many authors are at present concerned with the problems of chemoreception [11]. There is still no single viewpoint, however, with respect to the mechanism of the action of various chemical stimuli. The majority of authors divide stimuli into 2 groups: the first includes hypercapnia and hypoxia as well as cyanide compounds, the second acetylcholine, nicotine and some others.

Many authors, in their attempts to approach the solution of the essential problem of chemoreception, chose the path of studying changes in metabolic processes which play an important part in the reception of the stimuli indicated [12, 9, 3].

It has been suggested [9] that the stimulus for chemoreceptors is a change of metabolism within the cells. The author supposed that there were two different mechanisms of chemical stimulus action on receptors. Substances belonging to the first group cause significant changes in cell metabolism which serve as chemoreceptor stimuli.

* In Russian.