CHANGES IN THE ELECTROENCEPHALOGRAM OF THE HEALTHY HUMAN SUBJECT DURING TRIGGER PHOTIC STIMULATION

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Investigations conducted in the absence of trigger photic stimulation have shown that the character of the response to an afferent stimulus depends on the phase of the cerebral α-wave at which the stimulus falls [6-12]. On the basis of these investigations it was postulated that the α-rhythm to some extent reflects the cycle of excitability of the nerve cells of the brain. The results of the application of trigger stimulation, differing advantageously from the ordinary methods of afferent stimulation in the strict timing of the stimulus to a particular phase of the brain potential, confirmed this hypothesis [1-5]. The investigations of N. P. Bekhtereva and V. V. Zontov [2-4] are particularly interesting from this point of view. These authors used a trigger device by means of which a photic stimulus could be applied both at the moment of intersection of the α-potential and the isoelectric line (coincident stimulation) and at various intervals away from this moment (stimulation with delay). They demonstrated the different reactions of the α-rhythm recorded in the EEG of the occipital region of the healthy human subject, depending on the phase of the ascending or descending limb of the α-wave at which the photic stimulus fell. Coincident stimulation led more frequently to an improvement in the definition of the α-rhythm, as shown by an increase in the amplitude of the α-waves and the greater regularity of the α-rhythm. Coincident trigger stimulation thus possessed synchronizing value. The effects of stimulation with delay were more varied. This variation was determined by the time of the delay and by the timing of the photic stimulus to correspond to different phases of the negative or positive half-wave respectively.

Unlike the authors cited, in the present experiments in conditions of trigger stimulation the author studied the dynamics of the rhythms of the healthy human electroencephalogram (EEG) recorded not by a monopolar occipital lead, but by various bipolar leads.

EXPERIMENTAL METHOD

Using a trigger system, recordings were made of the potentials with comparatively small (fronto-temporal temporo-central, and other intrahemispheric leads) and larger interelectrode distances (mastoid-frontal hemispheric leads, and occipito-central midline lead). The trigger system was switched on with a short delay after the moment that the potential crossed the isoelectric line (10-15 msec). Two variants of trigger photic stimulation were used: the stimulus fell in the ascending phase of the α-wave and in the descending phase of the α-wave. The change from one variant to the other took place without interruption. The trigger stimulus was applied for about 40 sec. The investigation was carried out with the subject's eyes closed, and the light source was moved to a distance of 15-20 cm from the eyes. The system of trigger stimulation used was slightly modified from that provided in the FD-1 (Leningrad) photostimulator by the engineer A. L. Arnautov. Altogether 40 apparently healthy persons aged 17-35 years were tested.

EXPERIMENTAL RESULTS

In the conditions of trigger photic stimulation two main types of reaction were identified in the healthy subjects: weakening of the intensity of the α-rhythm with a varied degree of its depression of disorganization, and an increase in the intensity of the α-rhythm.

Weakening of the intensity of the α-rhythm was manifested by a disturbance of its regularity, a lowering of its index, and a decrease in and instability of its amplitude (Fig. 1). Often it was accompanied by a slight increase in the intensity of the β-activity. Sometimes periods of weakening of the α-rhythm alternated with brief bursts of a synchronized α-rhythm, but this synchronization usually did not exceed the background level. This type of reaction was observed as a rule if the photic stimulus fell in the ascending part of the α-potential (it was observed in 34 of 40 cases, i.e., in 83%).

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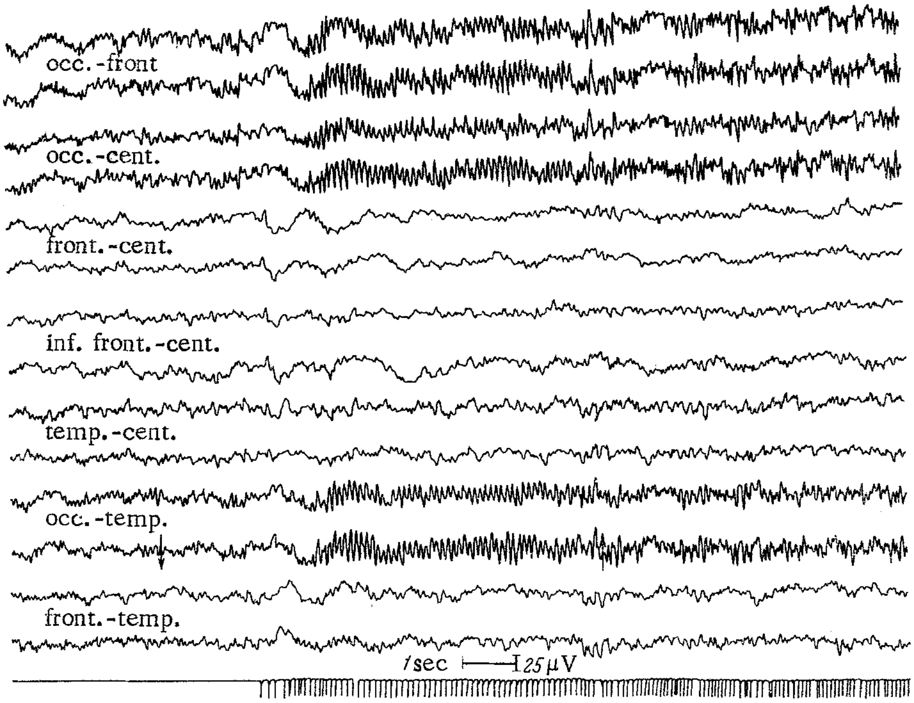

Fig. 1. Relationship between dynamics of the α-rhythm and the phase of the α-wave at which the photic stimulus falls. Explanation in text. The vertical lines on the lower tracing are markers of trigger stimulation. The arrow points to the area from which potentials were fed into the trigger system. The direction of the arrow up or down denotes that the photic stimulus fell in the ascending or descending phase respectively of the recorded waves.

In the other variant of trigger stimulation, when the stimulus fell in the descending phase of the wave, the intensity of the α-rhythm increased. This was manifested by its greater regularity, and by the increase in and greater stability of its amplitude (see Fig. 1, left part). The dynamics of the biopotentials in this case characterized the tendency of the nerve elements toward synchronized activity (observed in 30 of 40 subjects, i.e., in 75% of cases). Synchronization of the α-rhythm was usually more clearly defined when potentials recorded in leads including the occipital region were fed into the trigger system. The above-mentioned changes in the cerebral rhythms took place concurrently and uniformly in symmetrical leads from both hemispheres.

Besides the dominant α- and β-rhythms, sometimes slow waves—of the order of 5-6 per sec—are present in the healthy human EEG. They are more often recorded as small groups or as single waves of low amplitude, bilaterally and symmetrically in leads including the frontal and central regions. These slow waves are usually of greater amplitude in the leads with long interelectrode distances, when one of the electrodes lies in the frontal or central regions (occipito-central sagittal and parasagittal leads, or mastoid-frontal and mastoid-central leads, for example). However, the maximal amplitude of the slow waves, even with considerable interelectrode distances, usually does not exceed 20-25 μV, and it may often be less than 20 μV. Slow waves with an amplitude of 25-30 μV are found only in the younger age group (17-18 years).

Since trigger photic stimulation was directly linked with the intrinsic rhythms of the brain, naturally not only the α- and β-waves dominating the EEG, but also the slow waves described above, could generate photic stimuli and undergo changes. The dynamics of the slow waves in the conditions of trigger stimulation, like the dynamics of the α-rhythm, was determined by the relationship between the stimulus and the phase of the slow wave. If the photic stimulus coincided with the descending phase of the slow wave, the slow activity was not significantly modified. When, however, the photic stimulus fell in the ascending phase of the slow wave, usually the slow waves recorded in the original background in all the leads including the frontal and central areas were slightly emphasized. The intensification of the slow activity in these circumstances was more marked in the leads with greater interelectrode distances. It was usually manifested as a small increase in the number and amplitude of the slow waves (Fig. 2).

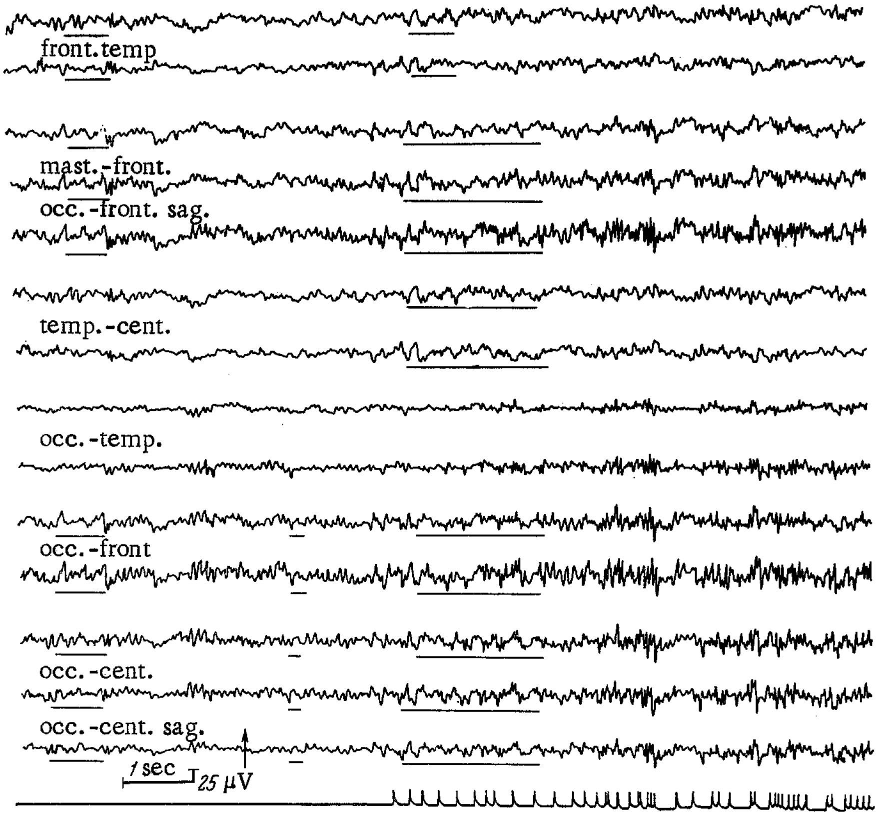

Fig. 2. Increase in the intensity of the slow waves during trigger photic stimulation. Legend the same as in Fig. 1.

The increase in the amplitude of the slow waves during trigger stimulation in healthy persons usually did not exceed 5-7 μV. Even with considerable interelectrode distances, the amplitude of the slow waves in these circumstances did not exceed 25 μV, and only in a few cases, in younger subjects, did it reach 30-35 μV. The changes in the slow activity during trigger stimulation were always similar in character and they took place simultaneously in the two hemispheres. Interhemispheric asymmetry, as in the case of reactions of the α-rhythm, was not observed.

An important feature was that the slow waves of the background activity were emphasized during trigger stimulation mainly if potentials recorded at considerable interelectrode distances (in these cases mainly the occipito-central sagittal lead or mastoid-frontal hemispheric leads) were fed into the trigger circuit. Large interelectrode distances are known to facilitate the detection of the electrical activity of deep structures. Bringing the electrodes closer to the midline was evidently a factor which facilitated the recording of this activity still further. Very probably, therefore, this slow activity reflects electrical processes taking place at the level of the subcortical nuclei and the structures of the brain stem.

It is an interesting fact that the relationships between the stimulus and the phases of the α-waves and of the slow waves leading to intensification of these two forms of activity were directly opposite: the α-rhythm became more marked if the stimulus fell mainly in the descending part of the α-wave; the slow waves, on the other hand, were usually intensified if the stimulus fell in the ascending phase of the slow wave. Evidently in the cases of these two types of waves, characterized by different periods, the afferent stimulus fell in different phases of the cycle of excitability of the nerve cells of the brain.

Let us now consider certain quantitative characteristics of the reaction. Changes in the rhythms of the brain may develop comparatively quickly after switching on the trigger stimulation. The latent period of the reaction in the overwhelming majority of subjects ranged from 0.15 to 0.2 sec. Only in a few cases did it reach 0.3-0.4 sec. The mean value of the latent period of the reaction was 0.2± 0.14 sec.

The action of the trigger photic stimulation continued for a short time after stimulation ceased. Usually this period was of the order of 0.5 sec, reaching 0.7-0.8 sec only in individual cases. The mean duration of the after-effect of trigger stimulation was 0.5± 0.2 sec.

The short period of the after-effect was followed by a phase of depression of the α-rhythm as a reaction to the cessation of the action of light, and the original activity was then restored. The duration of this depression was always longer than the period of the after-effect of trigger stimulation, and it varied in the different subjects from 1 to 3 sec. Only occasionally was the duration of depression of the α-rhythm less than 1 sec or greater than 3 sec. The mean value of the period of depression of the α-rhythm was 1.3 ± 0.8 sec.

Hence, corresponding with reports in the literature, different types of reaction of the rhythms of the healthy human EEG were discovered, depending on the relationship between the stimulus and the phase of the brain potential. Both the qualitative and the quantitative characteristics of these reactions were determined.

The results confirm the views expressed by a number of earlier investigators, namely that the α-rhythm reflects the cycle of excitability of the nerve cells of the brain. This conclusion may evidently be extended also to slow waves of the theta type, often present in the healthy human EEG.

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All abbreviations of periodicals in the above bibliography are letter-by-letter transliterations of the abbreviations as given in the original Russian journal. *Some or all of this periodical literature may well be available in English translation.* A complete list of the cover-to-cover English translations appears at the back of the first issue of this year.