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TRANSLATION

OPPOSITE CHANGES IN ELECTROPHYSIOLOGICAL REACTIONS
OF THE HUMAN BRAIN IN ADOPTING THE FREQUENCY OF
LIGHT FLASHES AT VESTIBULAR AND OPTOKINETIC STIMULI

By

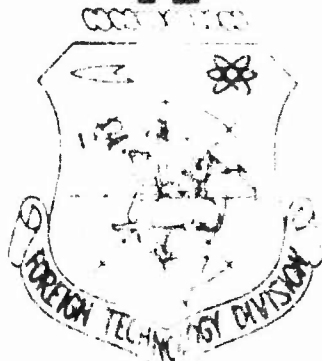
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**OPPOSITE CHANGES IN ELECTROPHYSIOLOGICAL REACTIONS OF THE HUMAN
BRAIN IN ADOPTING THE FREQUENCY OF LIGHT FLASHES AT VESTIBULAR
AND OPTOKINETIC STIMULI**

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The reaction of cortical structures, connected with analysis of light signals, on the irritations of other modalities appears to be a substantial link in the problem of convergence, reaction and overlapping of impulsion, determining the state of excitability and analytical activity of the central sections of analyzer systems.

In role of one of excitation level indicators can be used a summary electric activity of the brain-encephalogram, which is used more often as an indicator of the functional state of the brain.

The investigation by V. A. Ilyanek (1962) showed, that the adoption by the brain of a light flashes rhythm, expressed in a rise in EEG oscillations amplitude, synchronous to the frequency of a pulsating light, appears to be even further demonstrative proof of the state of excitability of the stimulated structures. At the same time V. A. Ilyanek (1959, 1961a, 1961b) discovered

that the amplitude of the light pulsation frequencies reproduced by the brain is due to the characteristic of the light signal - its intensity, duration and frequency. I (Samsanova, 1961) have revealed that in this reaction is found adequate reflection also for the properties of daily and dusk vision of the human being. It is essential, that its change is correlated quite well with the data of psychophysiological experiments concerning the differentiation of these or any other properties of light signals.

Consequently, the reaction of adopting by the brain a rhythm of light flashes reflexes the activity of these cortical structures of the brain, which participate directly in the analysis of light stimuli; consequently by its change can be judged the state of excitability and about the analytical activity of brain structures, reacting to light stimulation.

On the basis of these prerequisites was set up the problem of investigating, with the aid of this electrical reaction, in adopting by the brain of the rhythm of light flashes, the excitability of visual centers under conditions of their reaction with vestibular-optomotorial system. The biological importance of this reaction is exclusively great, because it determines the position and orientation of human being and animal in space. It was assumed, that the amplitude of light flash frequencies reproduced by the brain will change monodirectionally as during vestibular, and as during optokinetic stimulations, because anatomically, and functionally direct and numerous averaged relationships have been long established between vestibular and opticomotorial systems.

According to certain data, the human encephalogram at vestibular stimulations changes slightly. We have not succeeded in discovering functions, in which would have been investigated changes in amplitudes of light flash frequencies reproduced by the brain at vestibular and optokinetic stimulations.

METHOD

The examined at the time of experimenting sat in a Barani chair, situated in a screened chamber. The experimenter with the aid of remote control, situated outside of the chamber, could regulate the rate of rotation of the system, rotating the chain from 1 to 18 per min., and change the direction of rotation. Vestibular irritations were produced by rotating the chain at slow speed, which was then increased gradually.

Around the chain was fastened a circular, uniformly illuminated white screen, by which in the experiments with optokinetic stimuli were moved black strips at a rate of 1, 2 per 1 sec..

During experiment with long lasting rotation (in case of the bands, in other case with the human rotating in the chain) to the round screen was periodically fed an achromatic flashing light of fixed frequency (in a range from 7 to 33 c) from a Soneokle pulse photostimulator.

For artifactless recording of EEG in the process of human rotation A. A. Marinichev created in our lab a special transient device, allowing to register w/o distortions at greater amplification the biopotentials of the brain at the moment of the very rotation.

In experiments were used unipolar sections occiput-ear, sinoiput-ear; EEG recording was realized on an ink-writing oscillograph from the "Al'var Co"; registered were also the frequency spectra of EEG of these areas of the brain, separated by the two-channel Walter analyzer, dynamics of EEG frequency changes, corresponding to the rhythm of light flashes, obtained by separating these frequencies by analyzer filters, as well as the frequency marker of band rotations, Barani chair and light flashes.

The experiment began with the recording of background EEG under conditions when the examined had his sight fixed on the uniformly illuminated screen, and

then under action of the flashing light. Then a rotation was imparted either to the chair, or to the bands, which remained stationary to this moment. In the process of their rotation within each 5-10 min. was registered the EEG w/o flashing light and at light flashes, lasting for 40 sec..

The amplitudes of EEG frequencies, corresponding to frequency of flashing light, were calculated by analyzer data, averaged by 40 sec., immediately prior to application of rhythmical light stimulation and during the period of such irritation. Their changes were judged by the magnitude ratios of these amplitudes. Such a method of analyzing results was used because at vestibular-optokinetic irritations the EEG frequency spectra under conditions of our experiments experienced in turn certain changes.

RESULTS OF INVESTIGATIONS

In the experiments was detected a change in amplitudes of flashing light frequencies reproduced by the brain at vestibular and optokinetic stimulations. Human rotation in the chair caused a reduction in amplitudes of EEG oscillations, corresponding to rhythms of light flashes, which is illustrated by the fragment of recording the experiment (fig. 1 B).

Rotation of bands led to an opposite effect - it was accompanied by a rise in amplitude of rhythmic light stimulation frequency reproduced by the brain in comparison with control EEG (Fig. 1, C).

A reduction in EEG amplitudes, synchronous to frequency of light flashes, began ordinarily immediately after beginning of human rotation and rose somewhat in the process of its further rotation (Fig. 2,A).

An increase in these amplitudes, which took place during the rotation of bands, was frequently intensified in the process of their rotation (Fig. 2,B), but in many investigated it was very considerable from the first moments of rotation, and later on it either remained as it was, or began relatively decreasing.

The contrast in change of amplitudes in EEG oscillations, coinciding in frequency with the rhythm of light flashes, at vestibular and optokinetic irritations was detected in conditions of separating EEG from occipital area of the brain on all eleven examined. Individual differences were expressed only in the degree of described changes—in some expressed more and in other less sharply.

The frequency of light flashes also produced a certain effect on the magnitude of the detected effect. This is illustrated by the diagram in fig. 3, plotted in the same way as the following drawing: as a unit was accepted a ratio of amplitudes of adopted by the brain rhythm of light flashing to the amplitude of the very same frequency in background EEG, measured prior to applying vestibular and optokinetic stimulants.

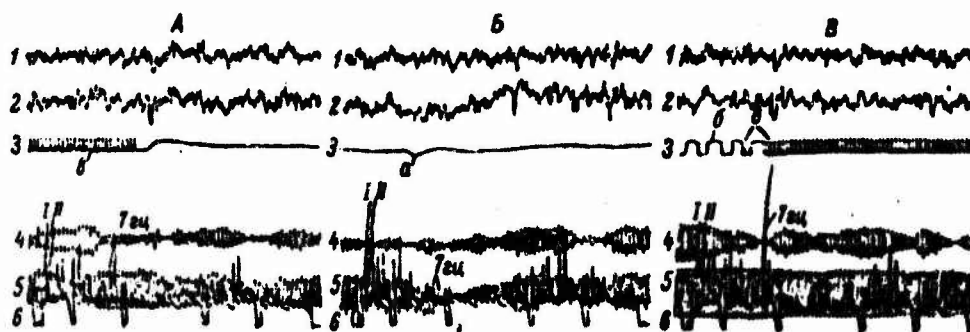


Fig. 1. Change in reactions of adopting by the brain of light flashing rhythms at vestibular (B) and optokinetic (B(C)) stimulants. A - control recording. Examined K. K. Experiments of Aug. 3, 1962. 1-EEG at occipital derivation; 2- at parietal; 3- stimulation marker; a-rotation of chair; b-rotation of bands; o-flashing light; 4-frequency of EEG oscillations 70, separated by analyzer filter at occipital; 5- at parietal derivation; 6- recording of EEG frequency spectrum with two channel Walter analyzer: I-occipital, II- parietal removal.

A change in this electrical reaction of the brain during rotation of the human or bands is expressed by average value analogous to the ratio of amplitudes for all measurements in each experiment, then in all experiments on all

investigated in comparison with the control ratio of amplitudes.

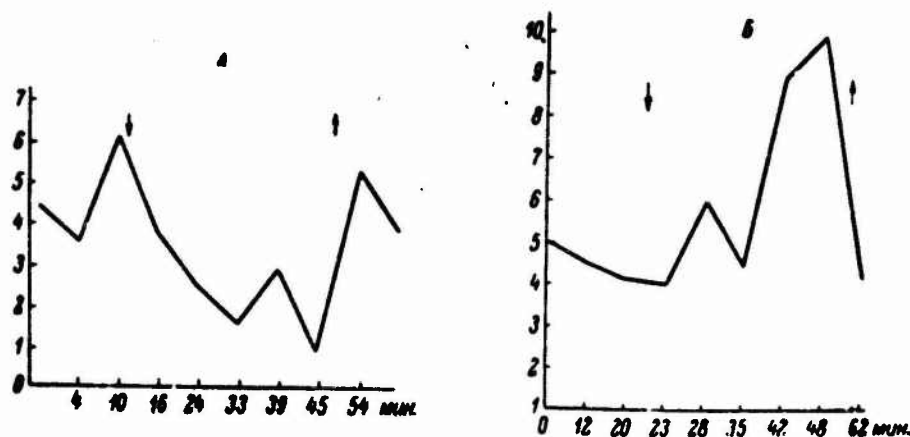


Fig. 2. Dynamics of change in frequency amplitude 7c reproduced by the brain at vestibular (A) and at optokinetic (B) stimulations. Tested A.S. June 18, 1962.

Along the axis of the abscissa - time of experimenting (in min.); along axis of ordinates - relative change in reaction of adopting by the brain of light pulsation rhythm 7c; as unit was accepted amplitude of EEG oscillations 7c w/c light flashes. Arrow down - beginning, arrow up - end of rotation of chair and band.

At a low rhythm of light stimulation (7 - 9 c) the amplitude of the frequencies reproduced by the brain decreased under the effect of vestibular stimulations less considerably, than at high (24 - 33 c) rhythm (fig. 3,a), and in experiments with band rotation the rise in amplitude was greater at low rhythm of light flashes, than at high rhythm (fig. 3,b).

Analogously, a no less sharply expressed effect of the opposite change in amplitudes of the adopted rhythm at vestibular and optokinetic stimulations was observed even when removing the biocurrents of the brain from the parietal area. At such a removal stimulation of the vestibular system caused a reduction in amplitude of EEG oscillations, synchronous to the frequency of light flashes, practically in all (in 10 out of 11) investigated persons (fig. 3,c), but the increase in amplitudes at optokinetic stimulations took place only in 70% of the investigated. In this case they increased much more at much higher frequency of light flashes (fig. 3,d).

It is necessary to mention, that the detected changes in amplitudes of

light flash frequencies reproduced by the brain was observed in the absence of noticeable symptoms of vegetative and vestibular disorders among all of the investigated persons.

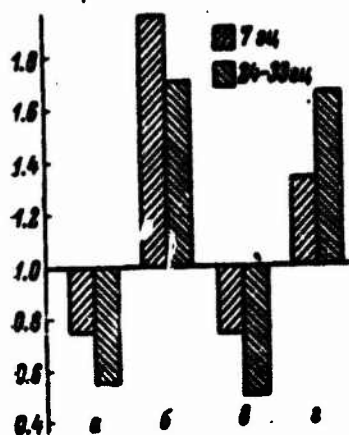


Fig. 3. Diagram of change in amplitudes of light flash frequencies reproduced by the brain (average data of experiments on all investigated, experiments 1962).

a-at vestibular; b-at optokinetic stimulations in conditions of removing from occipital area; c- and d-respectively at very same stimuli under conditions of removing from parietal area of the brain. Along axis of ordinates: ratio of amplitudes of frequencies produced by the brain in background EEG prior to applying vestibular and optokinetic stimuli.

As was said, by the change in reaction of adopting the brain of light flashing rhythms can we judge about the state of excitability of definite cortical brain structures, reacting to light stimulations. The presented materials indicate that it experiences changes under the effect of vestibular and optokinetic stimulations. In first case it drops immediately after the beginning of applying stimulants, and in second - it increases.

This difference in change of excitability can have in its bases features of anatomophysiological bonds of vestibular and optomotorial systems with higher level of visual analyzer. At present

time (JUNG 1962) it was established that in optokinetic reactions the selective and prevailing importance is played by the visual system, and the vestibular system effects only in a modulating manner the visual change in optomotorism.

The great act of visual distinction is inseparably connected in a human being with the movement of the eyeballs, i.e., excitation of muscular apparatus of the eyes, the activity of which is thus always combined with the activity of higher levels of the optical analyzer. Application of light stimuli

raises the excitability of cortical structures of the visual system, which is expressed, especially, in the intensification of amplitudes of EEG oscillations, corresponding to the frequency of light flashes. Combining stimulation of eye retina with the change in light and darkness, created by alternation of black and white bands over the screen, with the movement of the eyeballs, following the movement of these bands, even more increases the excitability of cortical structures of the occipital area of the brain and leads to even greater increase in amplitudes of light flash frequencies reproduced by the brain. A reduction in these amplitudes, caused by the stimulation of the vestibular system, indicates a depressing effect of such stimuli on the activity of cortical structures of the visual area of the human brain. According to newest data (Szentagothai, 1962), in addition to the direct bonds between vestibular and eye-moving centers, were established numerous direct relationships of vestibular center with reticular formation, particularly in areas, pertaining to premotorial ocular system. The presence of large and direct bonds between vestibular apparatus and reticular formation, to which even the optical system converges, allows to assume, that the effect of the vestibular system of the cortical structures of the brain, is possibly, due to the averaged effect of stimulating the reticular formation, although the vestibular system has a representation also in cortical structures of the brain of mammals (Walzl, Mountcastle, 1949) and that is why direct relationships are possible between representatives of visual and vestibular systems.

Relatively more considerable is the rise in amplitudes of light flash frequencies reproduced by the brain, observed in conditions of removing from occipital area of the brain at optomotorial stimulations, and relatively greater reduction in amplitudes, accompanying the stimulation of vestibular system at parietal removal, gives basis to assume, that the processes caused by stimula-

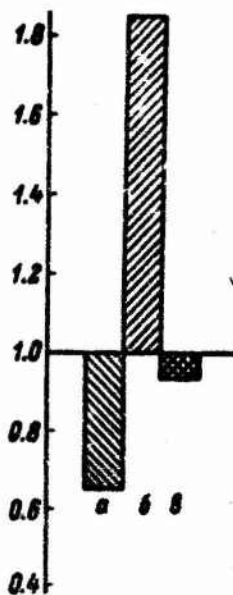


Fig.4. Change in amplitudes of light flash frequencies reproduced by the brain (average data of experiments on investigated in 1962). a-vestibular, b-optokinetic stimulations, c-simultaneous use of both stimuli. Remaining designations same as in Fig. 3.

in opposite directions.

The opposite of the effect of vestibular and eyemotorial links of this system on the adoption of light flashes by the brain, reflecting the level of activity of cortical structures of the visual analyzer, indicates a considerable complexity in the interaction between three systems - visual, vestibular and optomotorial, which determine orientation of human and animal in space.

As is known, the vegetative and eyemotorial apparatuses represent a single well coordinated system, but the results of our investigation show, that their interaction with the visual system is in no way synonymous - decrease in excitability of the latter, caused by vestibular stimulations, is levelled to a known degree by optomotorial stimulations.

A known confirmation of this assumption is the latter series of experi-

tion of the oculomotorial system, are more connected with the specific visual area of the brain, and the processes, developing in the parietal area, are more conjugated with the vestibular system.

In this way, the basic result, obtained in this investigation, is the contrastness in the reaction of adjusting the cortical rhythm to the stimulation of various links of the vestibular-eyemotorial system: stimulation of the vestibular link and stimulation of one eyemotorial center changes the functional state of the cortical structures, connected with the analysis of light stimuli

ments, in which vestibular and optokinetical stimuli were applied simultaneously during human rotation in one direction and rotation of bands in opposite direction. The results of these experiments are presented in fig. 4. While the amplitude of the frequent light flashed reproduced by the brain at vestibular stimulations decreased considerably, and rose considerably at optokinetic stimulations, under conditions of combining both stimulations it changed only by several percentages.

CONCLUSIONS

Results of this investigation give bases to assume, that the vestibular-oculomotorial system does not appear to be a simple reflectorial system, synonymously reacting to the stimulation of its various links. The nature of the interactions between these links is such, that the stimulation of vestibular and optomotorial links affects in an opposite manner the level of excitability of the cortical structures, connected with the analysis of light signals. The effect of the vestibular system of the visual one is expressed in its depressing effect on the cortical structures of the visual analyzer, and the eyemotorial system exerts an opposite activating effect on the very same cortical structures.

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