PROLONGED PERIODIC FLUCTUATIONS IN THE LEVEL OF ASYMMETRY OF EEG WAVE FRONTS IN VARIOUS TYPES OF BRAIN ELECTRICAL ACTIVITY

E. A. Zhirmunskaya and G. V. Makarova

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A study of the mean level of asymmetry of the ascending and descending fronts of the EEG waves showed that this statistical parameter undergoes periodic fluctuations in time [2-5, 7, 8]. These second-order fluctuations have been called "G" waves by E. Yu. Artem'eva.

The object of this investigation was to determine the changes in the "G" waves associated with three different states of brain electrical activity characterized by normal, hypersynchronized, and desynchronized EEG rhythms.

EXPERIMENTAL METHOD

The EEG was recorded in human subjects on ink-writing electroencephalographs (Alvar). Chlorided chemically pure tin electrodes were used to make simultaneous recordings from six bipolar leads (occipito-parietal, occipito-temporal, inferior parietal–inferior frontal, symmetrically for the left and right cerebral hemispheres). The electrode located nearer to the occiput was taken as active in each pair. The method of montage was such that an increase in electronegativity corresponded to an upward deviation of the recording pen. The winding speed was 6 cm/sec. Cuts of the curve 3 sec in duration were analyzed. The EEG was analyzed manually by the method suggested and developed by A. A. Genkin.

Changes in fluctuations of the mean level of asymmetry during 3 sec (the parameter Δ_3) in different types of EEG were studied by the correlation method. For this purpose the absolute values of Δ_3 measured for seven successive cuts of the EEG were ranked. The correlation coefficient for this numerical series was calculated by Spearman's formula

$$\rho = 1 - \frac{6\Sigma d^2}{N(N^2-1)},$$

where ρ is the coefficient of rank correlation; N the sum of the ranked variables; and Σd^2 the sum of the squares of differences between the ranks.

The correlation coefficients were calculated for corresponding points of the left and right hemispheres (transverse or interhemispheric connections) and for different points in the same hemisphere (longitudinal or intrahemispheric connections). The values of ρ obtained were divided into two groups: those below 0.3 (weak correlation) and those above 0.3 (average correlation). The significance of the differences was determined by the χ^2 criterion.

The following curves were analyzed: I) EEG with regular α-rhythm, with mean amplitude not exceeding 50 μV, and with well-marked zonal differences (9 subjects); II) EEG with α-rhythm, almost without clearly defined zonal differences between all regions of the brain, and with higher than normal amplitudes and index (10 subjects); III) EEG with predominance of β-activity and with irregular slow waves (10 subjects).

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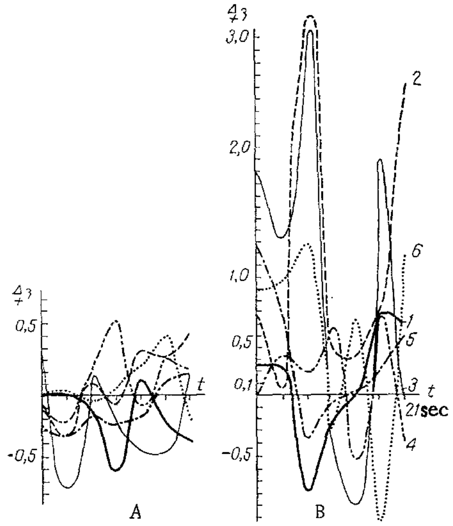

Fig. 1

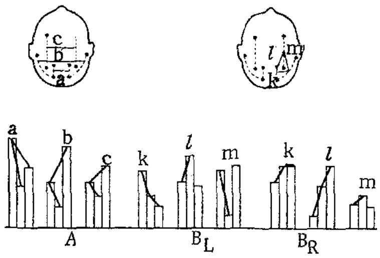

Fig. 2

Fig. 1. Fluctuations in Δ during a period of 21 sec at different points of the brain of a healthy subject (A) and of patient B-ko, a man aged 54 years (B). A) Regular α-rhythm of EEG with frequency 10 Hz and amplitude 40-50 μV, average index, and well-marked zonal differences. Medium frequency of β-activity at the level 20 μV. B) EEG shows slight diffuse changes indicating some disorganization of the α-rhythm with focal changes on account of the presence of θ- and Δ-waves in the right occipito-temporal and inferior parietal–inferior frontal regions. Diagnosis: brain tumor (arachnoidendothelioma) in the parieto-occipital region of the right hemisphere. Ordinate, values of Δ_3 in conventional units (1 conventional unit = 12.5 msec); abscissa, time (21 sec). 1) Left occipito-parietal, 2) right occipito-parietal, 3) left inferior temporal and inferior frontal, 4) right inferior parietal and inferior frontal, 5) left occipito-temporal, and 6) right occipito-temporal regions.

Fig. 2. Correlation coefficients of fluctuations in Δ_3. Shown above: arrangement of recording electrodes (black dots), montage of bipolar leads (broken lines), regions compared (thick continuous lines). Ordinate, mean correlation coefficients (in %); abscissa, leads compared. A) Cross comparisons: a) between left and right occipito-parietal regions, b) between left and right occipito-temporal regions, c) between left and right inferior parietal-frontal regions; B_L and B_R) longitudinal comparisons for right and left hemispheres separately: k) between left occipito-parietal region and left occipito-temporal region; *l*) between left occipito-parietal and left inferior parietal regions; m) between left occipito-temporal region and left inferior parietal-frontal region.

EXPERIMENTAL RESULTS AND DISCUSSION

The two graphs given in Fig. 1 show fluctuations in the mean values of Δ_3 over a period of 21 sec for six different points in the brain of a healthy subject and of a patient with a brain tumor.

As the graph shows, the orders of the values of the parameter Δ_3 in fact form second-order waves in time. The period of fluctuation of these waves is unstable and varied even under normal conditions. Under pathological conditions the pattern of fluctuations in Δ_3 with time is more complex still: the range of variations (or amplitude of mean values of Δ_3) increases sharply, whereas their period (or duration) remains as before.

Type of EEG \ Char. of EEG param.	Main form of assymtr. wave fronts	Change in ρ for G waves in connections			Change in two components of $R(\tau)_{max}$ for primary EEG recordings in connections			
					inter.		intra.	
		inter.	intra.		period. comp.	rand. comp.	period. comp.	rand. comp.
			L	R				
Hypersynchronized		↓↓	↓↑	↑↑	↑	↓↓↓	↑	↓↓
Desynchronized		↑↑	↓↑	↑↑	↓↓↓	↓	↓↓	↑↑↑

Fig. 3. Scheme of principal changes in some parameters in two types of EEG. Arrow indicates direction (rise or fall) of change in values studied compared with normal. Number of arrows indicates intensity of change. Inter.) interhemispheric; intra.) intrahemispheric.

A histogram of the values of ρ is given in Fig. 2. For symmetrical points of the left and right hemispheres (Fig. 2A) the values of ρ are below normal in the type II and above normal in the type III EEG. For different points of the left hemisphere (Fig. $2B_L$) the values of ρ are either below normal (k_{II}; k_{III}; m_{II}), above normal (l_{II}, m_{III}), or unchanged (l_{III}). For the same points of the right hemisphere the values of ρ are mainly increased (only in m_{III} do they remain at the same level as normally). It must be emphasized that under normal conditions the right hemisphere has lower values of ρ than the left (compare: l_I B_L and B_R or m_I B_L and B_R).

It is interesting to compare these results with those of correlation analysis of primary EEG recordings. Zhirmunskaya et al. [7] found that the type II (hypersynchronized) EEG is characterized mainly by a decrease in the cross-correlation coefficients for both interhemispheric and intrahemispheric connections. In the type III (desynchronized) EEG, the cross-correlation coefficient in the interhemispheric connections is reduced but that of the intrahemispheric connections, i.e., the longitudinal connections, is sharply increased. The pattern of these changes is compared in the scheme in Fig. 3, which shows that the two opposite states of brain electrical activity are characterized by different changes in the EEG parameters studied.

As yet there is no unanimity regarding the nature of the G waves described by Artem'eva. She associates them with nonspecific forms of cortical activation and shows that a change in the mean level of asymmetry and disturbance of the periodicity of the G waves obey the rules governing orienting reflexes. Similar views are expressed by I. G. Dallakyan.

The appearance of slow electrical potentials may be connected with phenomena of facilitation and inhibition in the brain. If the G waves are a real fluctuating process, they may be functionally connected not only with the orienting reflex, but also with other types of cortical activity. The changing pattern of distribution of the parameter Δ in sign and magnitude may evidently indirectly reflect the dynamics of excitation and inhibition in the cortical centers, which is determined by their variable functional state. Support for this hypothesis is given, in the authors' opinion, by the variations in configuration of the G waves and the independence of their dynamics in different parts of the brain, as is shown by the individual graphs and reflected in the changes in correlation coefficients shown in Fig. 3.

The possibility that the G waves may be connected with the very slow waves of potential described by Aladzhalova [1] likewise cannot be ruled out. In this case, the G waves may be responsible to some extent for the spatial organization of electrical potentials recorded on the EEG. However, another possibility is that spatial organization of brain electrical activity determined by a third factor (or group of factors) is manifested outwardly as the G waves.

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