CROSS-CORRELATION COEFFICIENTS OF ELECTROENCEPHALOGRAMS OF IRRADIATED RABBITS

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Cross-correlation coefficients of electroencephalograms (EEGs) combined with their other parameters (frequency, amplitude) provide a sensitive indicator of changes in the functional state of the cortex and reflect to some degree the character of the system of mutual relationships between cortical electrical activity at points where the EEG is recorded. The use of a general correlation index of the EEG is recommended as a means of evaluating the severity of a cortical lesion and the degree of recovery of its original state.

A promising method of describing cortical activity is by correlation anaylsis of the EEG [4, 6].

The writers have previously described [1, 3, 5] a system of automatic conversion, recording, and analysis of multiprocess information (the APROMIN system) and have shown that the state of cortical function of irradiated rabbits can be evaluated from electrophysiological indices calculated by the "Ural-2" computer.

The object of the present investigation was to obtain dynamic characteristics of the system of relationships between electrical activity of the principal zones of the rabbit cerebral cortex based on cross-correlation coefficients (CCCs) of the EEG.

EXPERIMENTAL METHOD

Seven rabbits were used and the experimental method was fully described previously [2]. Parallel recordings were made of 10, 12, or 14 EEGs on an "Alvar" electroencephalograph and on the magnetic tape of an APROMIN-16 multiprocess information converter. Recordings on magnetic tape were obtained as a consecutive 7-digit code. These data were introduced into the memory of the "Ural-2" computer and processed by a combined program which enabled the amplitude of the EEG, its mean frequency, its frequency indices, and the area and CCC of the EEG to be calculated. The results obtained from each record after irradiation were compared with the mean background values. The animals received whole-body irradiation by Co^{60} γ-rays: three rabbits in a dose of 1500 R, two in a dose of 1000 R, and two in a dose of 500 R.

EXPERIMENTAL RESULTS

To begin with the character of changes in the CCC of the EEG were studied for background recordings 28 sec in duration. CCCs of EEGs were calculated for 28 sec, for 4-sec intervals, and for 2-sec intervals. The most consistent from record to record were the coefficients calculated for the complete record as a whole. These will be implied when CCCs of EEGs are mentioned in the future. It should be pointed out

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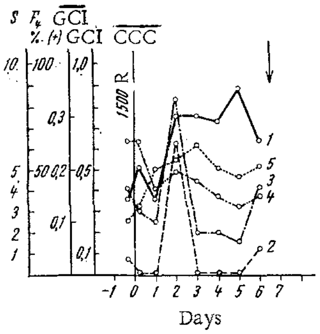

Fig. 1

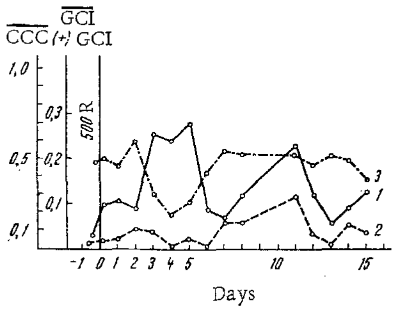

Fig. 2

Fig. 1. Dynamics of changes in EEG indices after irradiation of rabbits in a superlethal dose (1500 R): 1) GCI; 2) positive component of GCI; 3) mean CCC of EEG; 4) number of waves with frequency above 7.5 Hz as percentage of total number of EEG waves (F_4); 5) mean area of EEG (S) in relative units. Vertical line marks time of irradiation, vertical arrow time of animal's death.

Fig. 2. Changes in CCCs of EEGs after irradiation in sublethal dose (500 R): 1) GCI of EEG; 2) positive component of GCI of EEG; 3) mean CCC of EEG.

that for 14 EEG leads the computer calculates only 91 coefficients (for all mutual pairs of EEGs): seven interhemispheric for symmetrical points, 42 interhemispheric for diagonal points, and 21 coefficients of intrahemispheric connections for each hemisphere. The computer also prints the arithmetic mean value of the CCC of the EEG for the whole cortex.

The dynamics of the changes in the average CCC for the whole cortex in a rabbit irradiated with γ-rays in a superlethal dose of 1500 R is illustrated in Fig. 1. The same figure shows the dynamics of changes in the area of all the EEGs and the dynamics of changes in one of the frequency indices.

Since calculation of the mean CCC gives no idea of its deviations in different directions from the initial value it was also decided to use a general correlation index (GCI). This index is obtained by adding all deviations of the CCC from their mean background values (absolute) and taking the average. All positive and all negative deviations are also added together separately and averaged. At each stage in the investigation, to describe the cortical response to irradiation this general index and its components were used extensively.

The greater the magnitude of deviation of the GCI of the EEG from its background value and the sharper the differences between its individual components, (the total positive and negative deviations) the greater the changes in activity of the mutual intracortical connection systems and the more severe the lesion.

It is clear from Fig. 1 that 24 h after irradiation in a superlethal dose the cerebral cortex of the irradiated rabbit was bound steadily for death, for the GCI of the EEG in this period was much higher than its background level, and the GCI components showed no tendency toward equilization. In that case absence of a phase of "relative normalization" [2] could be confidently deduced. It should be noted in particular that this phase was established without the use of loads.

The dynamics of changes in the GCI and EEG followed a similar pattern in two other rabbits irradiated in a dose of 1500 R.

After irradiation with 1000 R the dynamics of the changes in the EEG GCI of the irradiated rabbits was somewhat different in character. During the first 2-3 days after irradiation considerable deviations from the background were observed in cortical activity. After 4 days there was tendency for the GCI to diminish. However, this brief tendency was soon followed by a sharp increase in the EEG GCI and by death of the animals.

The dynamics of the changes in the GCI of rabbits irradiated by γ-rays in a dose 500 R is shown in Fig. 2. Both rabbits survived (about 20% of rabbits die after irradiation in this dose).

The transition from crisis to normalization of cortical activity is interesting. As in the previous cases the moment of crisis was characterized by high GCI values. The recovery period began by the GCI moving close to the background values and it ended with equalization of its components. Complete restoration of cortical activity could be deduced only when the positive and negative deviations (components) of the GCI were equal to the original background values. In the present case complete recovery took place after 30 days, although the phase of recovery was apparent 6-7 days after irradiation.

The results described at present reflect only the action of γ-rays on the animal's cortex as a whole, without spatial analysis. It has been shown that the CCCs of the EEG, combined with frequency and area indices of the EEG constitute a sensitive indicator of changes in the functional state of the cortex and reflect to some degree the character of interrelation between electrical activity in the zones of the principal cortical leads.

The general correlation index is recommended as a method of assessing the cortical response to harmful conditions (to assess the severity of the cortical damage and the degree of recovery of the initial state).

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