USE OF A COMPUTER DIAGNOSTIC SYSTEM TO ASSESS CEREBRAL CORTICAL FUNCTION IN RABBITS ON THE BASIS OF EEG DATA

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UDC 612.822.3-087.87

Computer evaluation of the state of cerebral cortical function in rabbits on the basis of EEG data enabled its particular features to be distinguished during dark and light adaptation of varied duration and during the action of pentobarbital, and also revealed individual differences in cortical activity of different rabbits. A system for automatic conversion, recording, and processing of multiprocess information (the APROMIN system) and a computer diagnostic system were used in combination for multistage processing of multiprocess information. The final results were presented as a two-dimensional dot display, reflecting multidimensional dynamic patterns of the state of cortical function in rabbits. KEY WORDS: electrophysiology; diagnosis; computers.

For an objective evaluation of the state of cerebral cortical function (CCF) electroencephalographic (EEG) data are widely used [9]. Modern methods of automation and computers are being used increasingly frequently for electroencephalographic research [1, 3]. The use of commercial universal computers makes it possible to take advantage of the facilities of mathematical analysis.

In this investigation an attempt was made to find a single quantitative method of assessing the functional state of the animal as a whole or of its individual systems, on the basis of as wide a range as possible of diagnostic indices, by taking as the example the computer evaluation of the CCF of rabbits on the basis of EEG data.

EXPERIMENTAL METHOD

Experiments were carried out on six rabbits weighing 2.5-3.5 kg. The fundamentals of the method were described previously [3]. The EEG was recorded on an electroencephalograph and on the magnetic tape of a multiprocess information converter of APROMIN-16 type [2]. The arrangement of the eight active recording electrodes is illustrated in Fig. 1. Monopolar recording was used (the reference electrodes were place on the nasal bones) or the EEG was recorded from zones of equal area (in this case the common passive point was a system of 15 grounded auxillary electrodes, indicated in Fig. 1).

The encoded data from the magnetic tape were led into the memory of a Minsk-32 computer and processed in accordance with a complex program described previously [1, 4]. The resulting bank of secondary information with the results of frequency, amplitude, correlation, and statistical analysis for each 30-sec cut of the EEG (about 200 indices) served as the basis for the individual diagnostic chart. To identify the CCF of the rabbits a computer diagnostic system developed in the Institute of Experimental Medicine, Academy of Medical Sciences of the USSR, was used [5-8]. In this system the results of diagnosis are obtained in the form of logarithms of probability (in a supplementary code) for each of the forms which the computer has been taught to recognize. The final result of this multistage computer analysis of the rabbit EEG is presented as a two-dimensional dot display reflecting multidimensional patterns of rabbit CCF based on EEG indices.

In the computer diagnostic system of the Institute of Experimental Medicine, Academy of Medical Sciences of the USSR, the whole range of changes in the value of each index is divided into seven gradations. The digit 1 codes the values of indices characteristic of the normal state of the test object, the digit 2 a very small deviation of the value of the index below normal and digit 5 a similar deviation above normal. Digits 3 and 6

Institute of Biophysics, Ministry of Health of the USSR, Moscow. (Presented by Academician of the Academy of Medical Sciences of the USSR P. D. Gorizontov). Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny, Vol. 86, No. 8, pp. 250-253, August, 1978. Original article submitted November 18, 1977.

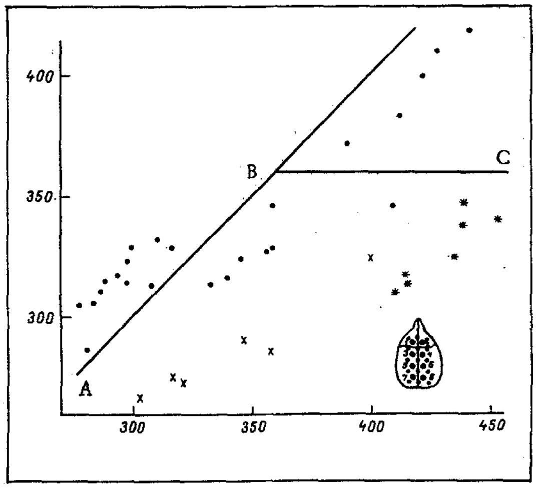

Fig. 1

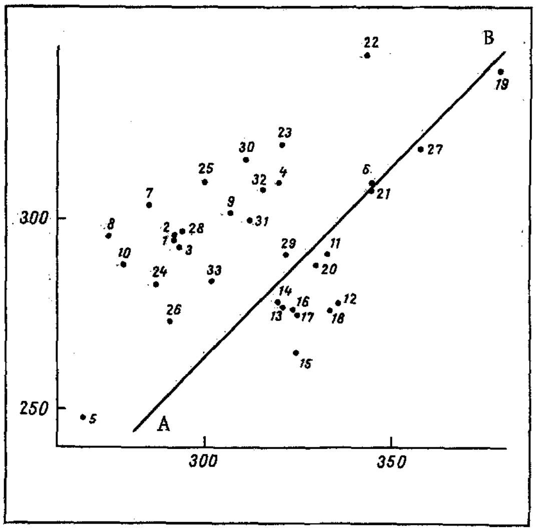

Fig. 2

Fig. 1. Computer diagnosis of CCF of rabbits. AB, BC – conventional lines separating functional states. On the right of line AB – dark adaptation for 3 min; on left – light adaptation for 3 min; above line BC – dark adaptation for 30 min. Dots denote data obtained for rabbit No. 1, crosses data for rabbit No. 2, asterisks data for rabbit No. 3. Bottom right – scheme showing arrangement of recording electrodes. Active electrodes shown by larger dots with numbers. Ordinate, logarithm of probability for dark adaptation; abscissa, logarithm of probability for light adaptation.

Fig. 2. Dynamics of CCF level of rabbit receiving pentobarbital. Points 1-10 denote initial state (10 records at intervals of 3 min); points 11-20 represent record obtained 10 min after injection of pentobarbital (10 records at intervals of 3 min); points 21-33 represent next record at intervals of 10 min. AB – conventional line of separation. Dose of pentobarbital 0.01 g/kg. Remainder of legend as in Fig. 1.

code average deviations from normal, and digits 4 and 7 considerable deviations; 0 indicates absence of information on the value of the index in the given investigation. Only these code numbers can be found in the computer diagnostic chart. With this strict formalization of the initial data independence of the type of test object and the character of the indices is ensured and a purely formal compiling of diagnostic charts for artificial (model) states of the object becomes possible. An advantage of such models is that they can be reproduced in any diagnostic system and scales of functional states can be created with fixed reference points for extreme and intermediate model situations.

If the values of the indices for the normal state are unknown, the range of changes of values is divided purely formally into gradations. It was in this way that the EEG data were coded. However, in this case investigations are carried out only on the comparative plane, and the artificial charts in these comparisons play a secondary role.

EXPERIMENTAL RESULTS AND DISCUSSION

As a first step the CCF of the rabbits was investigated during dark adaptation of two different durations: 3 and 30 min. From the results of computer processing of each record computer cards were compiled (20 cards for each state). Similar cards were compiled for rabbits kept in an illuminated room (lit by an opal 100-W electric lamp at a height of 1 m above the rabbit's head). For learning purposes 20 cards were used only for 3-min dark adaptation and light adaptation, together with artificially compiled cards. The results of computer diagnosis of the cards used for learning in the case of rabbit No. 1 are shown in Fig. 1, which demonstrates sufficiently clearly the spatial separation of the cards belonging to different forms of CCF in rabbit No. 1. The results of separation of the cards of three different rabbits kept under identical conditions are shown in the same figure. This spatial separation of the cards may be considered to be due to individual differences in the cortical activity of these rabbits. Cards of rabbit No. 1, relating to dark adaptation for 30 min, are shown in Fig. 1, but these cards were not used in the learning set. Nevertheless, spatial separation was observed:

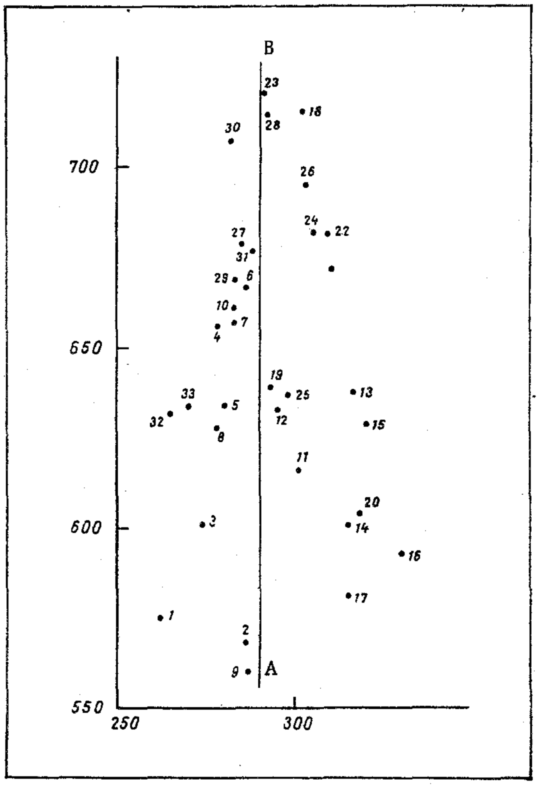

Fig. 3. Computer evaluation of CCF based on artificial diagnostic forms. Points 1-10 – initial state (10 records at intervals of 3 min); points 11-20 – record 10 min after injection of pentobarbital (10 records at intervals of 3 min); points 21-33 – next records at intervals of 10 min. AB – conventional line of separation. Dose of pentobarbital 0.04 g/kg. Ordinate, logarithms of probabilities for single artificial form; abscissa, logarithm of probability for artificial form from sets of four.

points reflecting the CCF of rabbit No. 1 with marked inhibition and excitation lay on different sides of the average state of rest. In the writers' opinion, later in this way it will be possible to make a quantitative assessment of the level of CCF and of the body as a whole by the use of appropriate multiprocess information.

Cards corresponding to dark adaptation of rabbits for 3, 9, and 15 min were reliably separated. This high sensitivity became possible as a result of graphic (spatial) representation of the results of the investigation. A two- and three-dimensional space (or more – depending on the number of forms of learning) enables the separation of closely similar functional states to be clearly presented and observed even when such separation would be difficult on the basis of the same numerical data, but presented in tabular form.

To study changes in the dynamics of the CCF of rabbit No. 1 pentobarbital was injected intravenously in a dose of 0.01 g/kg body weight. The results of multistage computer processing of the experimental data are shown in Fig. 2. Points 1-10, characterizing the CCF before administration of pentobarbital, reflect the zone of initial CCF. Points 11-20, characterizing the dynamics of the CCF levels under the influence of pentobarbital, form another zone which can be separated conventionally from the zone of initial states by the line of separation AB. Points 21-33 show the gradual return of CCF to the zone of the initial state. The effect of pentobarbital on the cortex lasted about 1 h. Cards 1-33 did not participate in the learning set, but separation was carried out on the basis of real forms of 3-min dark and light adaptation (Fig. 1).

The results of investigation of the dynamics of CCF of rabbit No. 5 before and after injection of pentobarbital in a dose of 0.04 g/kg are shown in Fig. 3. The EEG was recorded with a passive point from 15 grounded auxillary electrodes. Points 1-10, forming multidimensional patterns of CCF before injection of pentobarbital, were located on the left of the conventional vertical line of separation AB. Under the influence of pentobarbital the CCF changed suddenly and the points were shifted appreciably to the right of line AB. Only about 3 h later did the CCF of rabbit No. 5 return in a complex manner to the zone of the initial level (points 32-33).

On the basis of these results it can confidently be said that the use of computer diagnostic systems for the assessment of the functional state, not only of animals but also of man, on the basis of as wide a group of diagnostic indices as possible – general clinical, biochemical, electrophysiological, hematological, etc., is both practicable and promising.

The use of artificial standards for different levels of functional state affords new opportunities for the comparative quantitative evaluation of the functional state of heterogeneous test objects, even in the absence of the necessary set of real cards for learning.

It has become possible to obtain results such as those described above mainly through the use of multistage processing of much larger banks of information than were used previously.

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