ADAPTIVE BIOREGULATION IN SOME CHRONIC NERVOUS DISEASES

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Experience of the use of adaptive bioelectrical control systems in clinical neurology has demonstrated their suitability for the treatment and prevention of pathological manifestations of brain electrical activity in epileptics (spike-wave complexes, groups of high-amplitude slow waves) and also to correct pathological tremor of Parkinsonian type. These changes are based on conditioned-reflex mechanisms. Biologically controlled autostimulation can be used for the treatment of chronic nervous diseases in conjunction with other methods.

The method of adaptive bioregulation or instrumental "training" has been used chiefly in physiological research [3, 6, 8]. Meanwhile, the application of controlled "training" of physiological systems of the body would be of definite practical importance. This is particularly true for the control of pathological states which, because of their long duration, have acquired some degree of stability [1, 2].

The object of this investigation was to determine whether this method can be used, and with what prospects, in certain chronic nervous dieseases.

EXPERIMENTAL METHOD

The technique of adaptive autoregulation was used to treat the epileptiform activity of epileptic patients and to correct pathological tremor of Parkinsonian type.

The organization of the investigation was designed for a closed system of automatic control. Negative feedback was provided between the pathological manifestations (EEG parameters, tremograms, or envelopes of the electromiogram – EMG) and various external factors. Because of the negative feedback, these factors were activated synchronously with the appearance of the pathological features requiring correction. The external factors were signals, some of which were purely informative (sound, light) while others incorporated elements of a negative motivational character (electrical stimulation of the skin and warning the patients that these signals were the result of the pathological manifestations). The block diagram of the organization of adaptive autoregulation illustrated in Fig. 1 was drawn up on the basis of the

TABLE 1. Regression Equations Obtained from Results of Investigation of Patients

Patients	Equation of regression line	Degree of significance (P)
E.	Y = 235—13,4 X	<0,002
A.	Y = 218—5,6 X	<0,01
S.	Y = 24,6—3 X	<0,05

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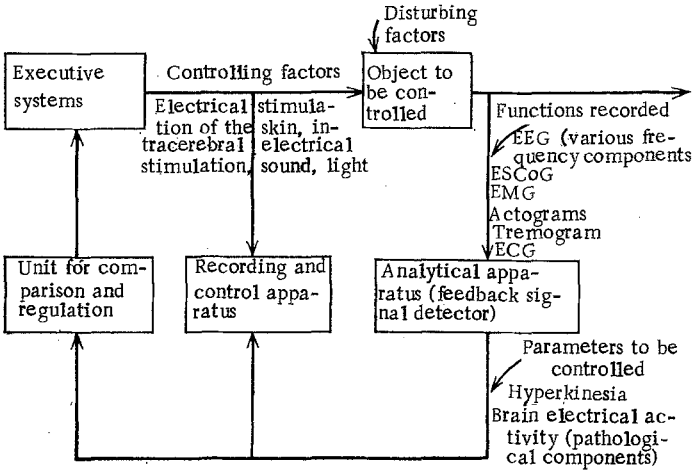


Fig. 1. Block diagram of organization of adaptive bioregulation (explanation in text).

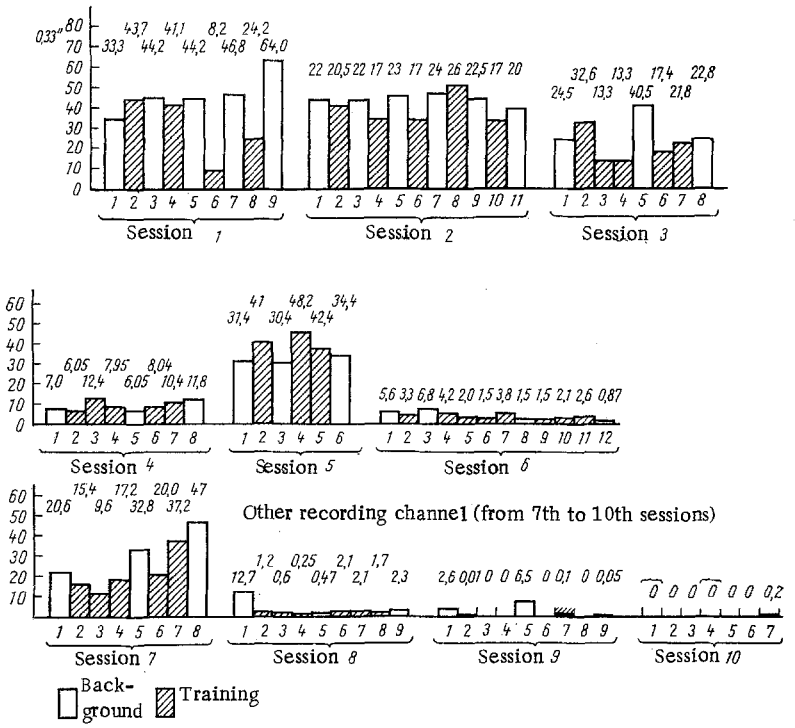
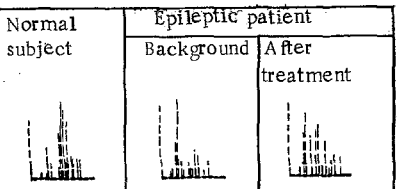


Fig. 2. Dynamics of expressiveness of Δ-activity in epileptic patient throughout the training period. Abscissa, No. of frames during session; ordinate, intensity of Δ-waves (in conventional units). Sessions 1-6) dynamics of Δ-activity during training of temporal region, sessions 7-10) dynamics of Δ-activity during training of frontal region.

general structure of the automatic control system [7] with concrete modifications introduced by ourselves (A. S. Tsukerman). The parameters indicated in Fig. 1 were chosen with allowance for the concrete clinical features of each patient. The amplitude of the low-frequency component of the EEG, averaged over a period of time, the frequency of appearance of high-frequency spikes of epileptiform activity, and the frequency–amplitude characteristic curve of the actogram of the tremor were chosen as control parameters. The resultant signal was led to an analogue computer, where it was detected and integrated with different time constants. The transformed signal was compared by means of the special amplifier of the computer

A



B

F Hz	Factors I	II	I	II	I	II
1,98	66	59	89	-22	87	13
2,5	22	-90	80	-26	47	-7
3,9	42	-19	89	46	-36	-73
7,9	-84	10	2	21	-46	-16
10	-93	-2	33	-25	92	22
12,6	10	-86	27	-28	78	-32
20	21	-23	-3	98	76	-44
31,7	52	-60	-15	71	28	-67
D%	32,0	29,5	30,5	25,6	42,8	17,3

Fig. 3. Characteristics of dynamic spectra of EEG as shown by frequency (A) and factor (B) analysis in normal subject and in epileptic patient before (background) and after treatment.

with a constant standard voltage. The controlling factors (sound, light, electrical stimulation of the skin) were activated whenever the signal exceeded this level. Because of the specific nature of the controlling system and the object to be controlled, the system used could be classified as adaptive with an active self-regulation component in the patient. Activation of the external factors led to the active development of a new functional state of the brain and enabled the functions of the patient to be controlled in an assigned direction.

The results of "training" obtained were recorded and assessed by analysis of the pathological manifestations or of the signals of the external factors, for these were synchronized.

The conditions for the control of brain electrical activity and motor activity of the patients were identical, and only the parameters of regulation were changed.

EXPERIMENTAL RESULTS

To reduce the epileptiform manifestations of the EEG and thus to lower the epileptogenic predisposition of the brain, frequent training sessions were given to five patients with a long history (10-20 years) of epilepsy with major fits and of traumatic or inflammatory etiology. Epileptiform activity predominated in these patients in the temporal regions, and it was expressed as the appearance of spike-wave complexes or groups of high-amplitude slow waves, as well as spreading hypersynchronous paroxysms consisting of spike-wave complexes. The effects of training were individual and depended on the severity and character of the epileptiform brain activity.

The dynamics of the severity of the high-amplitude paroxysms of Δ-activity in the patient's EEG can be seen in Fig. 2, which demonstrates the results of the training of an epileptic patient. The training effect was seen particularly clearly by the 6th session when, because of the absence of Δ-activity, any further training was impracticable. On a change in the training channel (the left frontal instead of the left temporal region) training took place much faster.

The comparative distribution of the various frequency components of the EEGs of this patient and the healthy subject and also the results of factor analysis relating to the first training session (tests by P. V. Bundzen), are illustrated by Fig. 3. This shows clearly the predominance of α-activity in the normal

subject and of the low-frequency spectrum in the background investigation of the patient and a shift of the maximum of the frequency distribution of the EEG toward higher frequencies at the beginning of training. The results of factor analysis show that the most important factors determining the ratio between the various forms of electrical activity in the normal subject lie within the range of α-β frequencies, in the background investigations of the patient they lie in the low-frequency range, and during training there is a shift toward more normal values of the indices studied.

At the end of the instrumental training this patient had no generalized fits for one month (previously they had occurred daily), despite the discontinuation of all antiepileptic measures.

These results show that the adaptive system of the brain is characterized by a unique system of "escape" from manifesting negatively reinforced rhythms (in this case, Δ-activity) and, on the other hand, reproducing faster rhythms, i.e., activity directed toward restoring the normal EEG.

Similar results were obtained regularly during the investigation of patients with pathological tremor or Parkinsonian type.

In the course of training the intensity of the tremor became appreciably less and the periods of absence of tremor, by contrast, became longer. To determine the general tendency in the distribution of these values, they were assessed by regression analysis.

A description of the regression lines for the patients studied is given in Table 1 where Y represents the degree of intensity of the tremor and X the serial number of the session.

The investigations showed that biologically controlled autostimulation leads to a statistically significant decrease in tremor of Parkinsonian type. However, tremor as a symptom of predominantly subcortical origin could not be completely abolished in the course of training.

There is thus reason to suppose that the method of adaptive autoregulation can be used and, in some cases, is effective as an additional form of treatment in clinical neurology.

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