ANALYSIS OF BRAIN FUNCTION UNDER THE INFLUENCE OF BEMITIL BY METHODS OF PATTERN RECOGNITION THEORY

Yu. G. Bobkov, A. I. Machula,
Yu. I. Morozov, and E. G. Dvalishvili

UDC 612.821.014.46:[615.31:615.272].08

KEY WORDS: bemitil; pattern recognition theory; electrical activity of the cat brain

On the basis of data obtained by a behavioral technique the writers put forward some ideas on the character of the effect of bemitil on individual components of the system organizing behavior [7].

In the investigation described below, to continue the analysis of the effect of bemitil on CNS activity, besides behavioral parameters, we also recorded some electrophysiological parameters.

EXPERIMENTAL METHOD

Evoked potentials (EP) in the visual, parietal association, and secondary somatosensory areas of the neocortex in response to presentation of conditioned stimuli in cats trained by a conditioned-defensive reflex technique to respond differentially to structured visual stimuli were studied by means of implanted electrodes.

Bemitil was injected intraperitoneally in a dose of 30 mg/kg. Brain electrical activity was averaged by means of a specialized PARK 42-02 computer. Averaging was done on 10 realizations. Subsequent analysis of the experimental data was carried out on a universal computer.

The following behavioral parameters were recorded: differentiation of short-term and long visual stimuli (DSS and DLS, respectively), latent periods (LP) of response to differential (LPD) and single (LPS) stimuli, decision making time (DMT) and the number of intertrial responses (ITR).

EXPERIMENTAL RESULTS

Recording EP showed that after injection of bemitil the amplitude of the N_1, P_3, and N_3 waves was reduced in the visual area and that of waves N_1 and N_3 was reduced in the somatosensory area. In the association area waves N_1 and N_2 were reduced and wave N_3 was increased ($r = 0.55$-0.58).

A decrease also was observed in KP of waves N_1 and P_2 in the visual cortex, an increase in LP of the N_1 wave in the somatosensory cortex, and an increase in LP of waves P_1 and N_1 in the association area.

Bemitil thus changes several electrophysiological and behavioral parameters characterizing different aspects of the goal-directed behavioral response. Meanwhile difficulties arose connected with matching of the behavioral and electrophysiological parameters, since data on individual components characterizing behavior do not allow the behavioral response to be looked upon as a unique and integral complex object.

The response of the animal is expressed not as a change in individual parameters, but as fluctuation of parameters constituting a single oscillating system [8]. Accordingly, what is important for the organism is not to find certain parameters within a certain range of values, but the ability to so regulate its own parameters that equilibrium with the environment is maintained in different situations [1]. Thus, for a complete and correct description

Research Institute of Pharmacology, Academy of Medical Sciences of the USSR. All-Union Research Center for Medico-Biological Problems in the Prevention of Drunkenness and Alcoholism, Moscow. (Presented by Academician of the Academy of Medical Sciences of the USSR G. N. Kryzhanovskii.) Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny, Vol. 104, No. 11, pp. 574-576, November, 1987. Original article submitted February 20, 1987.

 0007-4888/87/0011-1558$12.50

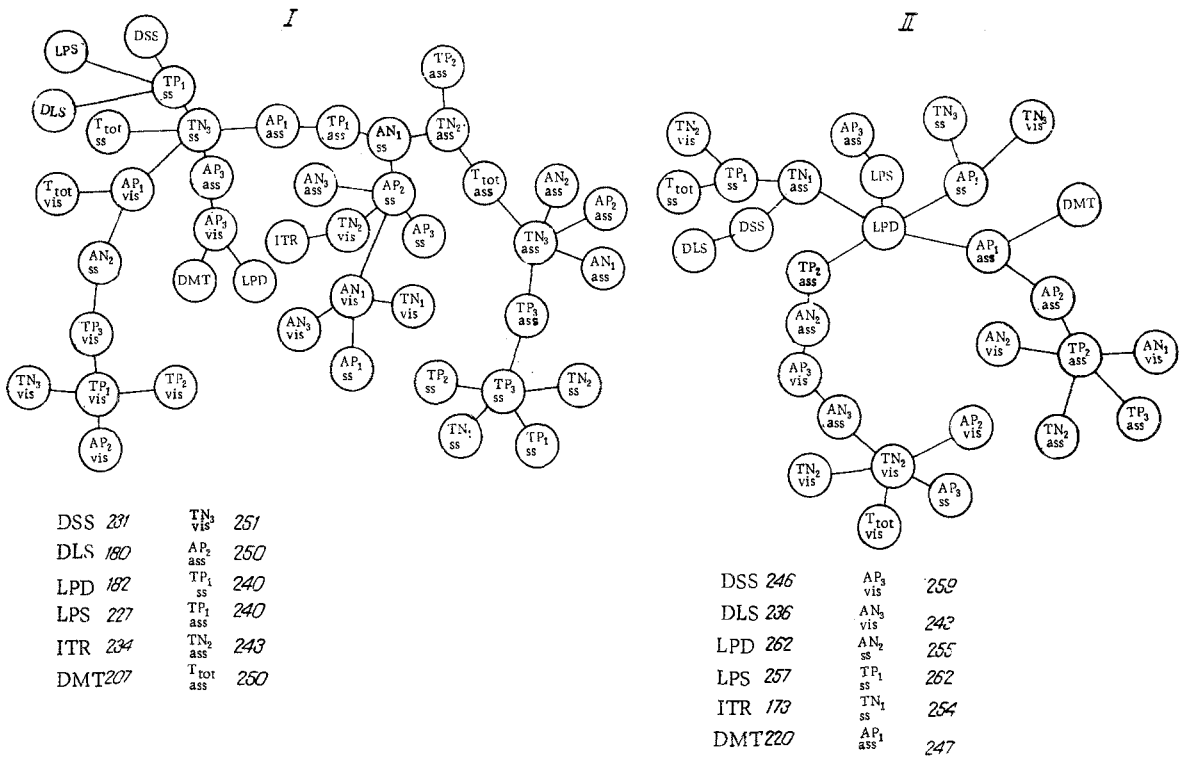

Fig. 1. Structure of functional states before (I) and after (II) injection of bemitil.

of behavior it is important to characterize not so much changes in individual parameters of the system as the principles acting between individual oscillating elements, and in that way to determine the state arising during realization of a behavioral response through the level of interconnection between the elements of such a system. Consequently, it is not the individual parameters of the object characterizing the state of activity of its elements that are described, but the interconnection between their changes arising in the course of activity [5].

To achieve this description of the object, we used methods of pattern recognition theory [3]. This method is based on a number of procedures: the linearization and scaling of each feature; introduction of a measure of connection (or distance) between the linearized features; calculation of the different degree of significance (of weight), whose value is inversely proportional to the sum of the distances of one feature from the other features; the discovery, on this basis, of combinations of the most valuable features; characteristics of the state of the object studied in multidimensional space; calculation of distances between individual objects.

One of the most effective methods of the pattern recognition theory is the method of cluster analysis [4]. If this method is used the result of analysis of the whole set of distances between features is reflected in the form of an unoriented, open graph, with the appearance of a dendritic tree. The apices of the dendrite reflect features and the distances between them are chosen in accordance with conditions of minimality (i.e., functional closeness) compared with the remaining distances between features of the given object. The weights of the features reflect the degree of their interconnection in the whole set of features used to characterize the state: features with the greatest weights are most closely interconnected with the other features; a set of connections of features with the greatest weights can be taken as a measure of interconnection between the elements of the given object, in a certain state. This analysis of characteristics enables the vague concept of "state of the organism" to be defined. Subsequent work with the graph consists of breaking the least close connections, distinguishing nodal elements, and thus distinguishing independent functional combinations, which can already be regarded as relatively uniform formations. Data obtained on objects in similar states were used for analysis.

The analysis of the experimental data conducted in this way showed that the background state is characterized by a certain level of interconnection, by the presence of several in-

dependent functional combinations. Features characterizing differentiation are most closely connected with one another and with LPS parameters. These parameters are most closely connected with those reflecting the temporal characteristics of analysis of visual information in the somatosensory cortex, as well as the initial stages of its analysis in the visual cortex. DMT and LPD have no close connections with the remaining set of features, and the same can also be said of the number of ITR. There are certain clearly defined clusters which contain elements characterizing the activity of one zone of the neocortex (Fig. 1a). Injection of bemitil caused an increase in interconnection between all features of the set; there was also an increase in connection with the remaining set of features characterizing DLS and LPD; the number of ITR was reduced, and behavioral features most clearly connected with features characterizing activity of the association and somatosensory areas within a wide time interval. DMT, just as in the background, had no close connections with other features. Meanwhile features reflecting activity of individual zones of the neocortex were not so homogeneously grouped as in the background (Fig. 1).

Thus the action of bemitil is characterized primarily by an increase in the degree of connection between all functional elements, which is responsible for the more stable solutions to problems facing the system. At the same time, it must be pointed out that under the influence of bemitil the importance of the process of arrival of visual information in the visual region of the neocortex is reduced and the importance of activity of the association region is increased. Consequently, the effect of bemitil on the construction of a physical model of the visual stimulus, which we observed, is unconnected with its direct effect on sensory structures, but is mediated through its effect on other processes, when it has, in turn, a constant correcting effect on analysis of the physical properties of the outside world [6]. Under the influence of bemitil, a less important role than in the background period also begins to be played by emotional factors, as is shown by reduction of the statistical weight of the number of intertrial responses [2]. Analysis of the experimental data, using the methods of pattern recognition theory thus showed that the state arising after injection of bemitil differs considerably from the background state, evidence that the behavioral response is realized in different ways by comparison with the background, and it may be connected with the effect of bemitil on the energy metabolism of nerve tissue discovered previously [7].

LITERATURE CITED

1. R. M. Baevskii, Prediction of States on the Borderline between Normal and Pathology [in Russian], Moscow (1972).
2. K. V. Bardin, The Problem of Thresholds of Sensitivity and Psychophysical Methods [in Russian], Moscow (1976).
3. S. N. Braines and V. B. Svechinskii, Problems in Neurocybernetics and Neurobionics [in Russian], Moscow (1968).
4. B. S. Duran and P. L. Odell, Cluster Analysis, New York (1974).
5. V. N. Reushkin, Cybernetics of the Living: Man from Different Aspects [in Russian], Moscow (1985), pp. 54-80.
6. J. Szentagothai and M. Arbib, Conceptual Models of the Nervous System [Russian translation], Moscow (1976).
7. Yu. G. Bobkov, V. M. Vinogradov, V. F. Katkov, et al., The Pharmacologic Correction of Fatigue [in Russian], Moscow (1984).
8. L. Bertalanffy, Problems of Life, London (1952).