RELATIONSHIP BETWEEN PHASES OF THE RESPIRATORY CYCLE AND FLUCTUATIONS IN AMPLITUDE OF CORTICAL POTENTIALS IN RABBITS

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The relationship between background and reactive fluctuations of visual cortical potentials and phases of the respiratory cycle was investigated in 15 unanesthetized rabbits by computer analysis. No constant correlation was found. In 90% of cases the correlation between the amplitude of fluctuations of potentials associated with the phases of respiration and the mean integral amplitude of the EEG was not more than 3%. A constant and closer correlation under normal conditions is an artefact, but repeated periods of a brief strengthening of this correlation are a characteristic feature.

Cortical evoked potentials (EPs) are a reflection of the synchronous activity of many neurons [9, 10]. Single unit responses to the same stimulus under natural conditions are highly variable. It is logical to assume that the mean response of a large number of neurons would be more stable. However, analysis of the EPs indicates that their variability under normal conditions is high [4]. What is the reason for the change in the responses of large groups of simultaneously working neurons under stable experimental conditions? In an attempt to answer this question, attention was directed to the slight degree of orderliness of fluctuations in amplitude of EPs in response to successive flashes. This orderliness may be due to the effect of other well known periodic processes in the body. These include fluctuations in the background activity of brain structures, and respiratory and cardiac rhythms.

The object of this investigation was to analyze the respiratory rhythms as a possible source of variability of the EPs.

EXPERIMENTAL METHOD

Experiments were carried out on 15 unanesthetized rabbits. Potentials from the visual cortex were recorded by monopolar and bipolar steel needle electrodes from the preliminarily scalped cranium. The cortical potentials and respiratory movements were recorded on a type ME-132V electroencephalograph. The sensor for respiratory movements was a type MPZ-1 attachment for measuring tissue impedance. Periodic components of the background potentials were isolated by means of a MAF-4B two-channel frequency analyzer. The results were analyzed by a type ATAS-401 four-channel computer programmed for averaging. The following were analyzed: the original EEG and pneumogram, and their harmonic components within the band of 2-4 oscillations/sec. Scanning by the computer was automatically triggered at an assigned phase of the respiratory cycle. Stimuli were generated by means of a type MS-2PS photophonostimulator. Flashes were synchronized with the beginning of scanning or were timed by a delay unit to occur at a particular phase of the respiratory cycle. In each experiment the period of observation was from 6 to 8 h.

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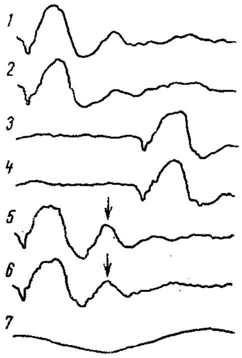

Fig. 1. Averaged evoked potentials in visual cortex of an unanesthetized rabbit. In control curves (1, 2) timing of flashes was independent of phases of respiration. In subsequent curves flashes were switched on automatically at the height of inspiration (5, 6) or after a delay of 500 msec (3, 4). Averaged recording of respiratory movements (7); upward deviation of line corresponds to inspiration. Duration of each analysis 1 sec; number of analyses 50.

EXPERIMENTAL RESULTS

In control experiments without photic stimulation visual analysis revealed no correlation between the phases of respiration and background fluctuations of the EEG. However, for each animal, without exception, periods of between a few seconds and 10 min in duration were observed during which a significant correlation between the two processes could be detected by computer analysis. The correlation between the phases of respiration and the EEG was assessed quantitatively with the aid of the formulas of information theory. From 5 to 15 measurements were made for each animal. In 90% of all measurements the amplitude of the fluctuations of potentials associated with the phases of respiration did not exceed 3% of the mean amplitude of the integral EEG. In isolated cases the degree of correlation reached 30%. Analysis of the harmonic components of the EEG was a much more effective method of detecting the correlation.

In the experiments with photic stimulation, the correlation between the character of the EPs and the phases of respiration in each animal was just as inconstant. An example of such a correlation in one of the experiments is given in Fig. 1. In contrast to the control (curves 1 and 2), there is an appreciable increase in the strength of the late components of the EP (indicated by arrows) when the flashes coincided with the height of inspiration (curves 5 and 6). The responses during expiration differed to a lesser degree from the control (curves 3 and 4).

The experimental results confirmed certain previously published facts concerning the background fluctuations in cortical potentials and their correlation with respiratory rhythms [1, 2, 6, 8]. Computer analysis of this correlation demonstrated its inconstancy. Only in certain periods was it possible to detect with confidence EEG waves which correlated with the respiratory rhythms. The stability of the respiratory rhythms on the EEG is most probably an artifact, according to a soundly based hypothesis [3, 5].

Changes in EPs dependent on the phases of respiration mainly affected their late components. Such changes were observed in all the experiments, but they likewise were not constant and occurred for short time intervals. Consequently, respiratory rhythms are a feeble source of variability of potentials evoked by flashes. Clearly other factors, and not these, essentially determine the periodic fluctuations in the character of the EPs. It is an interesting fact that on the average, the weak correlation between respiratory movements and fluctuations in the cortical bipotentials, becomes appreciably stronger during certain short periods of time.

LITERATURE CITED

1. A. M. Gurvich, Fiziol. Zh. SSSR, No. 4, 434 (1960).
2. Z. S. Dontsova, in: Problems in the Physiology and Pathology of Respiration [in Russian], Kuibyshev (1968), p. 40.
3. V. A. Kozhevnikov and R. M. Meshcherskii, Modern Methods of Analysis of the Electroencephalogram [in Russian], Moscow (1963), p. 70.
4. M. N. Livanov, in: Problems in Physiological Optics [in Russian], Vol. 2, Moscow–Leningrad (1944), p. 106.
5. A. I. Roitbak and S. N. Khechinashvili, Soobshch. Akad. Nauk Gruzinsk. SSR, 13, No. 9, 549 (1952).
6. A. I. Roitbak and S. N. Khechinashvili, Fiziol. Zh. SSSR, 40, No. 3, 262 (1954).
7. M. V. Sergievskii, Control of Regulation by the Cerebral Cortex [in Russian], Moscow (1955).
8. H. Berger, Arch. Psychiat. Nervenkr., 97, 6 (1932).
9. S. S. Fox and J. H. O'Brien, Science, 147, 888 (1965).
10. G. H. Fromm and W. Bond, Electroenceph. Clin. Neurophysiol., 18, 520 (1965).