SOME POSSIBLE FORMS OF INTENSIFICATION OF SLOW WAVES IN THE ELECTROENCEPHALOGRAM

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(Received June 17, 1955. Presented by P. S. Kupalov, Member Acad. Med. Sci. USSR)

In addition to the ordinary electroencephalograms used in clinical practice, frequent use is now made of electroencephalograms recorded from patients under determined conditions of cerebral activity.

In our research, which was undertaken at the suggestion of Prof. A. V. Lebedinsky, we recorded electroencephalograms while subjecting the patient to the action of indifferent light and sound signals, and then to conditioned light and auditory stimuli, and to their various combinations. The recording instruments were an oscillographic electroencephalograph and a Kaiser ink-writing electroencephalograph.

The conditioned reflexes were elaborated by the movement-speech procedure. We examined 90 patients suffering from tumors, tumor-like conditions, and acute closed traumatic injuries of the brain. In all we made 245 recordings.

It has been shown by a number of workers [2, 3, 5, 6, 9, 11] that various alterations in the electroencephalogram rhythms may be observed when the patients are exposed to stimulation.

In the present paper we report one of the possible variants of intensification of slow waves, which was very briefly described by V. S. Rusinov in 1948 [8] as a hypersynchronization effect.

In 50 examinations of 32 patients, the slow waves arising in response to exhibition of positive signals took the form of waves of large amplitude (up to 200-250 μv), diminishing later, of a periodicity of 0.2 to 0.6 seconds. In some of the patients the waves were at first of an angular form, and later assumed the usual rounded contours. These waves were distinguished by a certain rhythmicity and regularity of potentials, as compared with the ordinary slow waves.

When we first observed this phenomenon we were not convinced of the reality of its physiological origin. Considering the form and the nature of the waves, a purely physical explanation of the phenomenon seemed to be too tempting. As further material accumulated, however, we were obliged to abandon this explanation, the more so as the damping down of the oscillations was not always observed. We only became convinced of the physiological nature of the waves after we found that their appearance, the duration of their latent period, etc., depended on the condition of the subjects under examination.

Each burst of slow activity was 3-8 waves, and lasted for from 1 to 3-5 seconds, most often beginning and ending during the time of action of the signal, which was discontinued as soon as the patient gave a motor response.

The effect was very pronounced in certain of the patients, and in these cases its duration was also increased, the slow rhythmic waves persisting for 1-2 seconds after cessation of the action of the stimulus. In some cases the reaction consisted of two or even three bursts of slow wave activity, appearing in quick succession at intervals of 1-1.5 seconds, and usually only the first of these bursts appeared during the action of the signal (Figure 1). In two cases only did the rhythmic slow waves appear 4-5 seconds after the signal and its motor response reaction. Such effects were observed in patients during the first ten days after operation. Similar slow waves appeared in three patients after squeezing the bulb without previous elaboration of the conditioned reaction, but they were less pronounced.

High amplitude rhythmic slow waves were encountered in patients whose electroencephalograms showed pathological slow waves in the background rhythm, as well as in patients whose resting encephalogram showed no slow waves. When inhibitory signals were applied, the rhythmic slow waves were usually encountered when differentiations were being disrupted. Only in one case did the slow waves appear on exhibition of an inhibitory signal in the absence of any signs of disruption of differentiation. It hence seems that the form of slow activity observed in association with positive signals is a manifestation of the stimulatory process itself, arising under some special conditions, or else of inhibition of a different type of internal inhibition.

The hypersynchronization effect was observed by us chiefly in the frontal regions of the brain, as was also found by V. S. Rusinov [7]; in some cases, however, it was found for the whole of the cerebral cortex. When we applied visual conditioned signals, the rhythmic slow waves were most pronounced in the posterior parts of the frontal lobe and with the occipital lead. In some patients the slow waves were only recorded with occipital or parietal leads. Irrespective, however, of whether the motor response to the conditioned signal was made by the right or the left hand of the patient, the slow waves were more frequently registered from the right cerebral hemisphere.

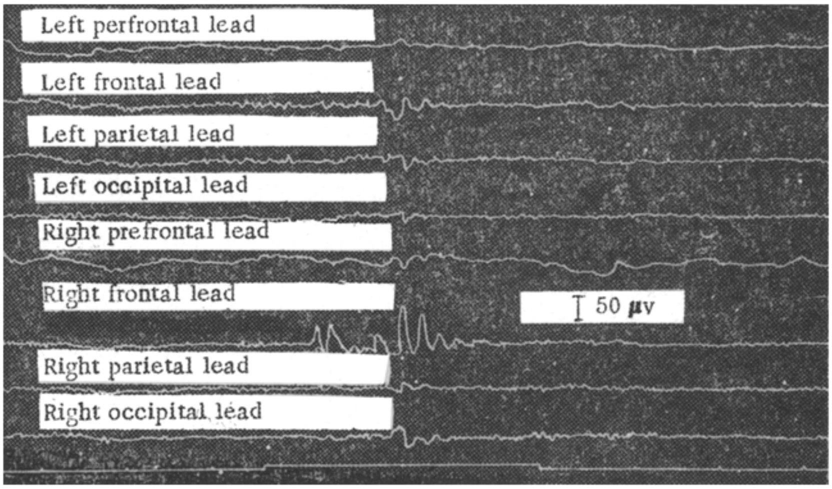

Fig. 1. Electroencephalogram of the patient M., suffering from an angioma of the right cerebellopontile angle.
Explanation of tracings (from above down): electroencephalogram of the left prefrontal region, of the left posterior frontal region, of the left parietal region, of the left occipital region, of the right prefrontal region, of the right frontal region, of the right parietal region, of the right occipital region, conditioned signal marker, for positive visual and auditory complex stimuli applied simultaneously.

Electroencephalograms of this type may be a consequence of the spreading of a single process over a large group of cells, viz., of the synchronized action of a large group of neurones. Such a process could equally well be a diffused stimulatory one, or an inhibitory process. Considering, however, that a characteristic feature of these waves is, apart from their high amplitude and their relative rhythmicity, the increase in their periodicity, which indicates a lowering of the lability of the nervous structures participating in the reaction, which should, in all probability, favor inhibition [1, 2, 12]. The localization of the slow waves chiefly in the right hemisphere, even when the motor reaction is effected by the left hand of the patient, puts the mechanism of interhemispheric induction among the possible explanations of the phenomenon. The reason for the regularity of the rhythmicity of the waves is not clear. We can only refer it to the facility with which rhythmic slow activity can be elicited under conditions which involve alterations in the interrelations of nervous processes in the cerebral cortex of animals [5, 13].

We observed a phenomenon, in the same research, which owing to its superficial similarity to the above-described phenomena was at first thought by us to be related to them.

After exhibition of conditioned signals, groups of waves appeared on the electroencephalograms of some patients, which were of the same form as the high voltage slow activity described above, but with a shorter period of oscillation, the frequency being of the order of the alpha rhythm. This was seen in its most typical form in patient K. In the early postoperational period, his electroencephalogram was very smooth, with no high-potential waves, and the delta and alpha waves seen before the operation were no longer in evidence. The case history of this patient showed that his postoperational condition was grave. Up until the time when the first electroencephalogram was recorded the patient was in a profoundly inhibited state, being very slow to answer questions, and giving monosyllabic answers, and he was very feeble and apathetic. Considering the clinical data together with the electroencephalograms, we came to the conclusion that the latter reflected an irradiation of inhibition throughout the whole of the cerebral cortex.

We were able to observe the appearance of alpha waves in response to positive conditioned stimulation, and after a protracted latent period. Further attempts at stimulation, involving the simultaneous application of two or more positive stimuli, elicited a retardation of the oscillations, with the appearance of large delta waves (Figure 2). Towards the end of the examination of this patient a single positive stimulus was sufficient to elicit waves of a greater period than alpha waves. Under these conditions stimultaneous exhibition of a positive stimulus and an inhibitory signal led to a rise in frequency of the waves (Figure 3). We should add, however, that a breakdown of differentiation took place after this, and we were not able to reestablish it subsequently.

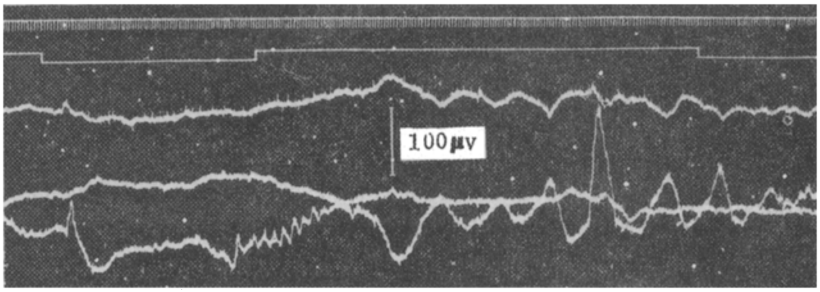

Fig. 2. Electroençephalogram of the patient K., recorded April 8, 1955. A recurrence of a tumor of the right temporal-parietal lobe was diagnosed. The cyst was evacuated on March 19, 1955, without removing the tumor. Explanation of tracings (from above down): time marker (1 second), signal indicating time of exposure to positive light (blue, red) conditioned signals, electroencephalograms.

How can we explain the appearance of an alpha rhythm in response to a positive conditioned signal, in the total absence of such waves in the background rhythm?

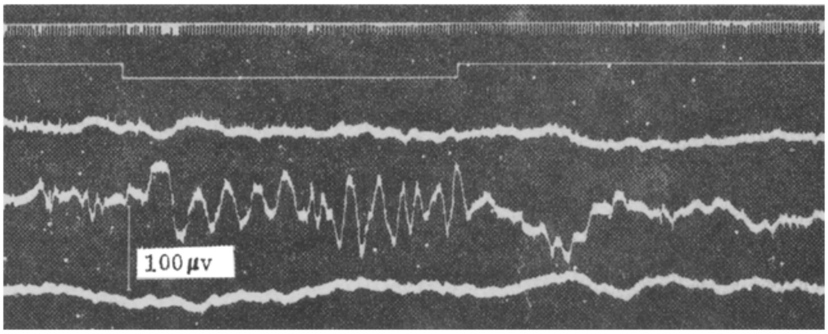

Fig. 3. Electroencephalogram of the patient K., recorded April 12, 1955. Explanation of tracings (from above down): time marker (1 second), signal indicating time of exposure to conditioned signals, viz., a visual complex positive stimulus and an auditory inhibitory stimulus, applied simultaneously, electroencephalograms.

As is known, the alpha rhythm appears in normal subjects both when the activity of the cortical cells is intensified and when it is depressed, with change in the conditions of functioning of the brain. The alpha rhythm thus represents a form of bioelectric activity which is manifested in certain definite functional states of the brain [2], and which characterizes the excitability of the cortical nerve cells [3, 4].

Exhibition of a conditioned signal exalted the excitability of the nerve cells to a level sufficient for the appearance of alpha waves. As has been shown, further intensification of the stimulus led to increase in the period of oscillation.

Why did the presentation of positive signals in most cases elicit slow oscillations of the delta wave type, although it was possible under similar conditions to observe the appearance, or the strengthening, of alpha waves?

I. P. Pavlov [8], in examining the interaction of nervous processes in the central nervous system by the conditioned reflex method, demonstrated the limiting role of an inhibitory process in the spread of an excitatory one. He emphasized that a delimiting function of this sort can only be fulfilled by a sufficiently powerful inhibition. Stimulation concentrated in certain definite regions of the cerebral cortex, although these vary from moment to moment, does not, in spite of constant broad irradiation, stimulate the vast majority of the nerve cells to a state of activity. This lowers the possibilities of development of superlimiting inhibition.

A. I. Roitbak [10] has, on the basis of the laws discovered by N. E. Vvedensky, also related dispersion of potential arising during direct stimulation of the cortex to its concentration by an inhibitory process.

V. S. Rusinov [11] has stressed the basic similarity of the mechanisms concerned in initiation of the fundamental forms of bioelectric activity of the brain. In considering the origin of alpha, delta, and beta waves, he believes that their periodicity depends on the number of cellular elements coming into play.

It is possible that the frequency of the oscillations observed by us was determined by the relative strengths of the stimulatory and inhibitory processes, and by the extent of irradiation of the stimulatory process in our patients. The truth of such an assumption is supported by M. N. Livanov's data [4] showing normalization of the electroencephalogram rhythms when the experimental animals were given bromide, as well as by our observation that the period of the slow waves is shortened when an inhibitory signal is added to a positive stimulus. The presence of a state of profound inhibition in the central nervous system of the patient K, at first limited excitations arising therein, and led to the appearance of alpha waves. In the given case, the role of the delimiter of excitation, was, in distinction from the normal conditions, fulfilled by superlimiting inhibition, possibly superadded to inductive inhibition. In other cases, a weak inhibitory process permitted the irradiation of excitations to a large number of nerve elements, evidently so causing an intensification of superlimiting inhibition of these elements, which found its physiological expression in the lengthening of the period of the oscillations.

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