ELECTROENCEPHALOGRAPHIC CHANGES INDUCED BY PROLONGED EXPOSURE TO SOUND

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The problem of noise attracts more and more attention because of the continuous increase of noise as an unfavorable influence of the environment. Observations on human subjects working in intense noise have shown that particularly with prolonged exposure to high frequencies a number of systems, notably the central nervous and the cardiovascular systems, may be affected [1, 5, 8, et al].

Very few studies have been made of the influence of noise on the activity of the different systems. Scarcely any work has been done on the mechanism of the disturbances referred to above.

We have made an attempt to apply the method of electroencephalography to determine the nature of the changes induced by intense high-frequency noise on the central nervous system, and to solve some of the problems concerned in the mechanism of these changes.

METHOD

The experiments were carried out on rabbits and dogs exposed to high-intensity sound for several weeks. Experiments were also carried out on human subjects exposed to sound for a shorter period. As a sound source we used a rotating metal drum containing pieces of metal. The intensity of the sound varied between 90 and 100 db. A frequency analysis of the noise showed that it constituted a high-frequency sound stimulus, the energy maximum occurring at a frequency of 2000-3000 cycles.

The potentials from the cerebral cortex were recorded by an "Al'var" ink writing electroencephalograph. In all cases monopolar leads were used. The potentials from rabbits were picked up by occipital, parietal, and temporal electrodes, and in dogs they were taken from the occipital and parietal regions.

Connection was made to the animals by the method proposed by G. T. Sakhiulina [6]. Before the beginning of each recording, a steel electrode with bakelite insulation was fixed to the skull. Only the terminal, 0.5 mm, was left uninsulated. The animals rapidly became adapted to the presence of the electrode, and as a rule scarcely reacted at all to its manipulation.

Before the animals were exposed to the intense sound, for several weeks they were made familiar with the circumstances of recording the electroencephalogram. It was not until a steady condition had been reached that they were exposed to the sound.

Electroencephalograms from human subjects were recorded in the usual way. The potentials were picked up by monopolar electrodes from the frontal, temporal, and parietal regions. The duration of the sound stimulus, which was produced by the noisy drum and a sound generator, varied from several minutes to several tens of minutes.

RESULTS

During the first days of the exposure of the rabbits to the sound, very characteristic changes occurred in the electroencephalogram. Instead of the relatively slow waves of various amplitudes which are normally found in rabbits, rapid oscillations of 60-75 cycles and an amplitude of 50 μV appeared. These changes were maintained for several weeks. Then waves at a frequency of 5-6 cycles began to appear with increasing frequency (in most of the animals the frequency was 5.5 cycles); the electroencephalogram presented a curve having a well-marked synchronized and regular rhythm. The voltage of these waves was 150-175 μV (Fig. 1). As the action of the sound continued, in some of the animals the amplitude of the waves increased somewhat.

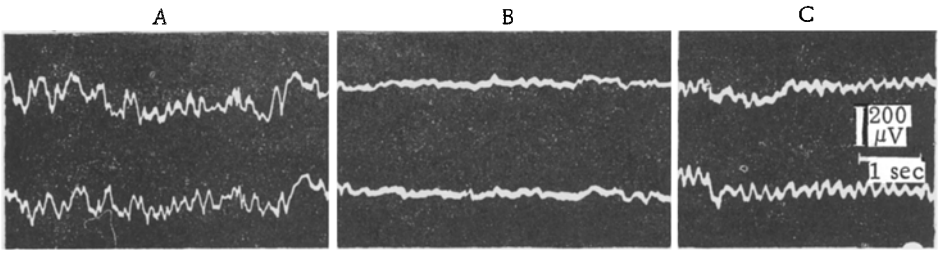

Fig. 1. Changes in the electroencephalogram of a rabbit during several days' exposure to sound. A) Before exposure to sound; B and C) during exposure; there is a marked desynchronization of the EEG, and a regular rhythm appears in the occipital lead.

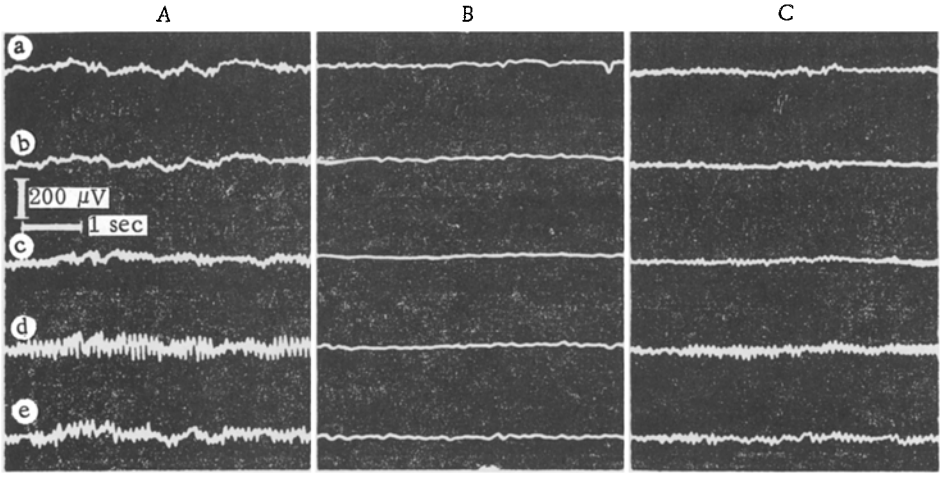

Fig. 2. Changes of the human electroencephalogram during exposure to intense sound. A) Before exposure to sound; B) 9 min after the onset of the action of sound; C) 20 min after the end of the exposure. a, b) Frontal leads; c,d) occipital leads; e) temporal lead.

In dogs exposed to sound it was found that there was an increase in the number of rapid oscillations to 75-80 cycles, and a change in their potential, which was usually reduced. In some experiments, a synchronized rhythm of a frequency of 4-6 cycles appeared.

In human subjects exposed to the same sound stimuli for the short period of 30 min, or to the action of a tone of 3000-5000 cycles for 2-3 min, even within the first few minutes a depression of the alpha-rhythm and the appearance of low-amplitude high-frequency oscillations representing a beta-rhythm appeared. As the sound action continued, the depression of the alpha-rhythm increased (Fig. 2). In most subjects which were observed, during the exposure both to the sound and the high-frequency tone, sharply pointed spikes could be seen to occur in the electroencephalogram. These potentials were recorded synchronously from various regions of the cortex, and were of the same amplitude in all the leads. After the sound had ceased, they continued to be recorded for several minutes, though their number decreased, and they disappeared entirely after 5-8 min.

In some human subjects the action of the sound caused regular synchronized waves having a frequency of 4-6 cycles to appear, just as in the animal experiments. The waves were unstable, and appeared only over short lengths of the curve. Possibly the instability is associated with the fact that for human subjects the sound acted for a comparatively short period.

Some of the electroencephalographic changes which we have observed have been described previously by A. Volkov [4], by Byugar [11], and by others, who found in both man and animals exposed to sound that there was a depression of the alpha-rhythm, and that slow waves and spikes appeared.

Having observed the appearance of well-shown regular rhythms in the encephalograms of both man and animals exposed to intense sound stimulation, we have attempted to analyze this phenomenon. Because these sort of

frequencies are associated with activation of the rhythmical electrical activity of the reticular formation of the brain stem [3, 9, et al.], we have attempted to reproduce them by injecting into a rabbit a solution of adrenalin hydrochloride, which is known to activate the reticular formation [10, 12, 13, et al.]. In the rabbit, the effect was to induce after a few minutes a regular rhythm of 4-6 cycles, i.e., it produced the same effect as did the action of intense sound. The results obtained agreed with the findings of I. P. Anokhina-Itskova [2], who observed the same effect when injecting adrenalin into rabbits.

The fact that under the influence of prolonged intense sound stimulation desynchronization is observed in many regions of the cerebral cortex, and that under these conditions slow regular rhythms appear, and the possibility of reproducing these rhythms by means of an adrenalin injection suggests that during the action of the intense sound there is an increasing activation of the reticular formation of the brain stem.

SUMMARY

Marked changes of cerebral electrical activity were observed to be induced by intense noise. In animals, high frequency oscillations appeared, and at certain times regular waves appeared in various cortical areas. In man, a depression of the alpha-rhythm, the appearance of a marked beta-rhythm, spike potentials, and a regular rhythm were observed. It is suggested that these changes are produced by activation of the reticular formation of the brain stem brought about by the action of intense sound stimulation.

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All abbreviations of periodicals in the above bibliography are letter-by-letter transliterations of the abbreviations as given in the original Russian journal. *Some or all of this periodical literature may well be available in English translation.* A complete list of the cover-to-cover English translations appears at the back of this issue.
