CHANGES IN THE OPTIC CHRONAXIE AND THE ELECTROENCEPHALOGRAM DUE TO DRUGS ACTING ON THE TRIGEMINAL NERVE ENDINGS

K. A. Bushtueva, E. F. Polezhaev, and A. D. Semenenko

Department of Clinical and Experimental Physiology (Head – Active Member AMN SSSR V. V. Parin) the Department of Communal Hygiene (Head – Prof. V. A. Ryazanov) of the Central Postgraduate Medical Institute (Director – M. D. Kovrigina), Moscow

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The reactions of the nervous system to an increasing intensity of excitation arising in response to sub- and superthreshold stimuli enable the general pattern of reflex activity to be established [1, 4]. In the study of this problem great importance is attached to comparison of the dynamics of the central processes in response to the action of stimuli on different peripheral analyzers, as well as to the quantitative evaluation of the level of excitation during stimulation of the same receptors.

Chemical substances present in the surrounding air are known to act on the different receptors of the upper respiratory tract. Some substances show a well-marked action on the receptors of the olfactory nerve, whereas others act mainly on the trigeminal nerve endings and, in contrast to the first which give rise to sensations of smell, they cause irritation as, for example, a tickling of the back of the throat, cough, and other effects.

In the present research we studied the reflex effect of a sulfuric acid aerosol, which is distinguished by a marked irritating action in the innervation zone of the trigeminal nerve.

As indices of the effect of this substance we used the EEG and the optic chronaxie. The sulfuric acid aerosol is one of the group of existing hazards. The determination of the threshold of reflex action of this substance by the changes in the EEG and optic chronaxie can, therefore, serve as the basis for the limiting permissible concentration of sulfuric acid in the atmospheric air in centers of population.

EXPERIMENTAL METHOD

In order to give a predetermined dose of the sulfuric acid aerosol, the method recommended by the Commission on the Limiting Permissible Concentrations of Atmospheric Pollutants [2] was used. At a short distance in front of the test subject's face, in a soundproof conditioned-reflex chamber, was suspended a cylinder through which air was circulated at the rate of 30 liters/min, passing through a system of filters which retained odoriferous substances present in the air in the building. The air was delivered by means of a rotating air pump. Air entered the cylinder, through which the subject breathed, continuously throughout the period of the investigation. At a given moment the addition of a definite concentration of sulfuric acid aerosol to the pure air was made by means of a system of cocks from the supply vessel.

The optic chronaxie was investigated six times at intervals of 3 min on a model GIF condenser chronaximeter, and between the third and fourth determination the subject inhaled air with the addition of a certain quantity of sulfuric acid aerosol for 2 min. As a rule the rheobase remained unchanged during the investigation.

The electrical activity of the brain was investigated by means of a 4-UN44-channel amplifier with a ChR-1 ink-recording attachment from the experimental factory of the AMN SSSR. The main response reaction which we used for evaluating the influence of the olfactory stimulus was desynchronization of the electrical activity or depression of the α-rhythm. During the time of development of the conditioned reflex, a light which caused desynchronization was used for reinforcement. The investigations were carried out on 10 healthy persons with normal olfactory function and with normal respiratory passages.

EXF 'F MENTAL RESULTS

The concentrations of sulfuric acid aerosol which, according to the verbal response of the subjects tested, had an irritant action (tickling at the back of the throat) were regarded as threshold values. The minimal dose of this substance to produce the threshold effect was 0.6 mg/m^3. In less sensitive subjects, however, its value was higher – 0.85 mg/m^3.

As shown by the optic chronaxie, an effect of the sulfuric acid aerosol on the central processes was also apparent when acting in a concentration of 0.6-0.85 mg/m^3.

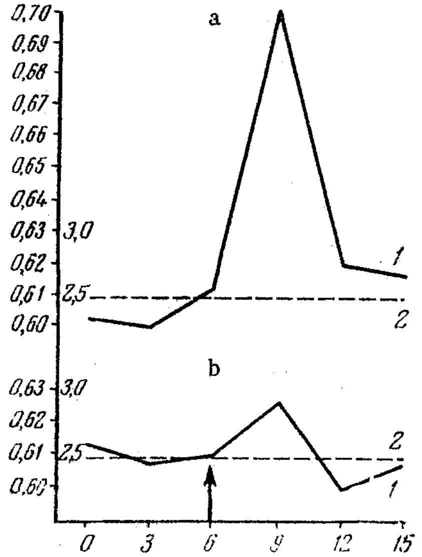


Fig. 1. Increase in the optic chronaxie following the use of sulfuric acid aerosols in threshold concentrations. On the axis of abscissas on the left is shown the chronaxie (in μf), on the right the rheobase (in v); on the axis of ordinates is shown the time (in min). The use of sulfuric acid aerosol in a concentration of 0.73-0.75 mg/m^3 is shown in (a) and in a concentration of 0.60-0.63 mg/m^3 in (b). 1 – chronaxie; 2 – rheobase. The arrow shows the moment of giving the sulfuric acid aerosol.

It can be seen in Fig. 1 that a sulfuric acid aerosol, in a concentration of 0.6-0.63 mg/m^3, causes an insignificant rise in the optic chronaxie. In their verbal response the subjects stated that, in these doses, the aerosol caused a vague sensation of tickling in the back of the throat. In higher concentrations (0.73-0.75 mg/m^3), the sulfuric acid aerosol caused a greater increase in the optic chronaxie, and in their verbal response the subjects stated that there was now an obvious tickling in the throat. When concentrations of 2.4 mg/m^3 and over were used, isolated bouts of coughing took place.

It follows from these facts that the influence of the sulfuric acid aerosol on the reflex reactions, as measured by chronaximetry, begins when the intensity of excitation which it causes is equal to that at which arises the specific reaction for this substance and its reflection in the verbal response. The influence of the sulfuric acid aerosol on the optic chronaxie showed a characteristic trend. On repetition of the investigation after an unequal interval of time in different subjects, the initial effect of an increase in the optic chronaxie disappeared. In the subject K., for instance, the initial value of the optic chronaxie was 0.60 μf. The use of a sulfuric acid aerosol in a concentration of 0.75 mg/m^3 caused an increase in the optic chronaxie to 0.71 μf. On the second investigation the degree of increase of the optic chronaxie was smaller (0.69 μf), and on the fourth it was insignificant (0.62 μf).

During the study of the electrical activity of the brain we were interested to learn whether the EEG would change during the isolated use of the sulfuric acid aerosol in subthreshold concentrations in accordance with the verbal response and the chronaximetry findings. The investigations showed that the isolated use of this substance in subthreshold concentrations did not cause desynchronization in the EEG.

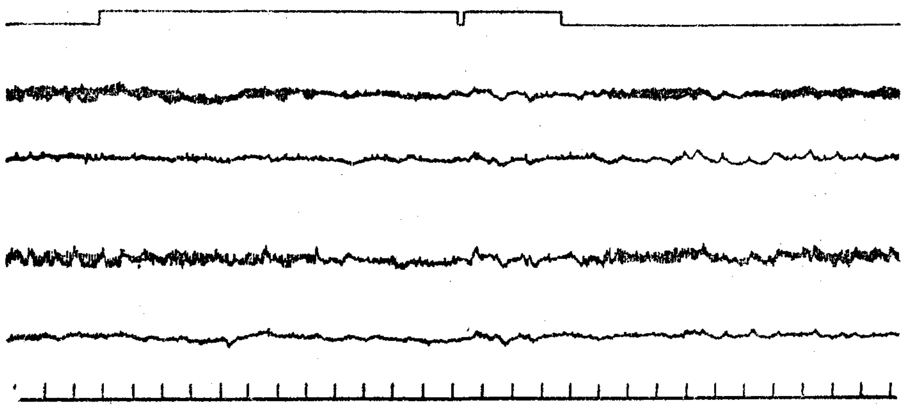


Fig. 2. Conditioned reflex desynchronization in response to the use of a sulfuric acid aerosol in a subthreshold concentration of 0.4 mg/m^3. Twenty third combinations of the action of the sulfuric acid aerosol with a continuous light. Legend (from above down): Stimulus marker, EEG of the occipital area of the right hemisphere, EEG of the temporal area of the right hemisphere, EEG of the occipital area of the left hemisphere, the same in the temporal area, time marker (1 sec).

In the cases when threshold concentrations of the sulfuric acid aerosol were used, desynchronization was observed in the EEG for 1-2 sec. The desynchronization was apparent both during the time of the isolated action of the sulfuric acid aerosol and immediately after the cessation of its supply into the air inhaled by the subject. The effect of desynchronization was unstable and after 2-3 repetitions it was completely extinguished; it was not restored even during the use of the sulfuric acid aerosol on the subsequent days of the investigation.

Changes in the electrical activity of the brain in the form of desynchronization of the EEG thus took place when the use of the sulfuric acid aerosol induced excitation of sufficient intensity to alter the course of other reflex reactions. We have in mind particularly the phosphene reaction, an index of which is the optic chronaxie.

From the results of our investigations the question arose whether subthreshold concentrations of sulfuric acid aerosol cause excitation in the central nervous system. The reply to this question was given by research in which a conditioned reflex change in the electrical activity of the brain was developed in response to subthreshold concentrations of this substance. As conditioned reflex stimulus we used a sulfuric acid aerosol in a subthreshold concentration of 0.4 mg/m^3. The action of the aerosol in isolation was continued for 15 sec, after which a continuous light was applied for 5 sec as reinforcement. A conditioned reflex was established at the 23rd combination of the sulfuric acid aerosol and the light (Fig. 2). During the use of the aerosol alone, desynchronization was observed in the EEG. If a threshold concentration was used as a stimulus, the conditioned reflex was established much more quickly. At a sulfuric acid aerosol concentration of 0.63 mg/m^3, the reflex was established after 6-8 combinations.

When the character of the electrical activity of the brain in response to the use of substances acting mainly on the trigeminal and olfactory nerve endings, respectively, in superthreshold concentrations* was compared, attention was drawn to certain distinctive features of the reaction to a sulfuric acid aerosol. When this substance, for instance, was used as a conditioned stimulus, it caused a less pronounced desynchronization than olfactory stimuli such as, for example, sulfur dioxide gas. The conditioned reflex change in the electrical activity was also less stable. It appeared after the sixth to eighth use of the sulfuric acid aerosol and was extinguished at the 10th-12th combination of the action of this substance with the light. A considerable difference was also observed during comparison of the rate of extinction of the effect on the EEG when substances acting on the olfactory and trigeminal nerve endings were used alone in superthreshold concentrations.

If the sulfuric acid aerosol was used in a concentration of 1.3 mg/m^3 or over, then in the case of development of a bout of coughing in response to such stimulation an increase in the degree of synchronization in the EEG was observed. With repeated stimulation, the act of coughing was depressed and desynchronization was observed in the electrical activity (Fig. 3a) which was completely extinguished after 5-8 applications of the aerosol. When sulfur dioxide was given in concentrations causing a bout of coughing, the degree of synchronization also increased (Fig. 3b). If this act took place against a background of desynchronization, this desynchronization gave way to synchronized electrical activity of the brain in the form of a changeover to α-rhythm (Fig. 3c). After the repeated action of sulfur dioxide, when the subject stated in his verbal response that he suppressed his bouts of coughing, marked desynchronization also appeared. Extinction of this change in the EEG, however, took place more slowly; it was completed after 15 applications of sulfur dioxide.

The investigations described above show that a sulfuric acid aerosol has in general the same effect on the optic chronaxie and the EEG as olfactory stimuli. The former differs in the lesser degree of the reflex effect and its more rapid extinction. These differences are evidently due to the unequal degree of corticalization of the central representation of the olfactory and trigeminal nerves.

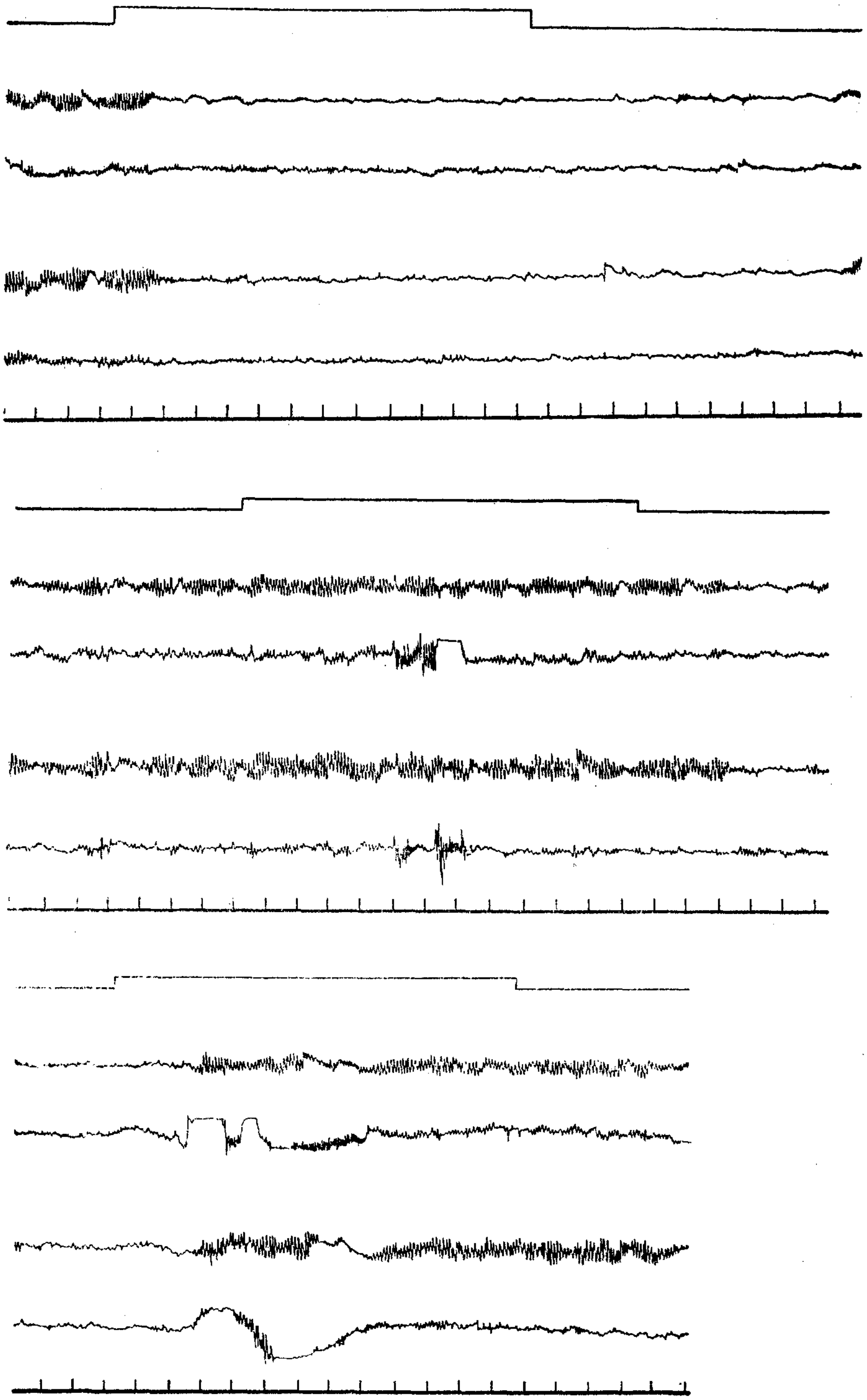
Impulses arising in response to stimulation of the receptors of the olfactory nerve are known to pass via the third neurone to the hippocampal area of the cortex [3]. This area is included in the system of nerve structures in which a continuous circulation of nervous impulses takes place. The peculiarity of the construction of the central representation of the trigeminal nerve is that it has a lesser degree of corticalization. Hence, with sub- and superthreshold doses of substances stimulating the endings of the trigeminal nerve, the resulting excitation changes the dynamics of the cortical processes to a lesser degree than olfactory stimuli.

SUMMARY

Substances stimulating the trigeminal nerve endings exercise on the central processes the same effect as olfactory stimulants. As distinct from olfactory stimulants, these substances, when employed separately, change the EEG and the optic chronaxie only at threshold concentrations (according to verbal reports of the persons under investigation). The elaboration of a conditioned reflex occurs following the combined action of subliminal concentrations of the sulfuric acid aerosol and light. Desynchronization of the EEG appears in response to the isolated action of the sulfuric acid aerosol. Recording of the cerebral electrical activity in combination with the method of conditioned reflexes enables the detection of that minimal intensity of excitation (provoked by subliminal stimulation) whose level is sufficient to affect the cortical activity.

* The effect of subthreshold olfactory stimuli on the reflex activity is discussed by us in a paper in the press.

a



b

c

Fig. 3. The variable electroencephalographic effect in response to the isolated use of substances acting on the olfactory and trigeminal nerve endings in superthreshold concentrations. a – Desynchronization in response to the repeated use of the sulfuric acid aerosol, causing a sensation of irritation without the development of a bout of coughing (concentration of sulfuric acid 1.3 mg/ m^3); b – increase in the degree of synchronization in response to the use of sulfur dioxide gas, causing a bout of coughing (concentration of sulfur dioxide 15 mg/ m^3); c – replacement of desynchronization by synchronization of the electrical activity of the brain in response to the action of sulfur dioxide, causing a bout of coughing (concentration of sulfur dioxide 15 mg/ m^3). Legend as in Fig. 2.

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