

CHANGES IN THE EEG DURING AND AFTER  
A COURSE OF CARBON DIOXIDE  
AND HYDROGEN SULFIDE BATHS

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The mode of action of carbon dioxide and hydrogen sulfide on the interoceptor terminations has been repeatedly investigated [9, 10, 14]. As part of a plan to investigate the receptor mechanisms and the nature of the processes underlying excitation it seems important to study the response of the cutaneous analyzer to the action of these stimuli. It is known that carbon dioxide and hydrogen sulfide are widely used in waters for prophylaxis and treatment of various diseases of the nervous system.

Many investigators attribute the changes occurring under the influence of the waters to the involvement of the central nervous system [1, 2, 3, 4, 5, 6, 7, 8, 11, 12, 13].

No electrophysiological studies have been made of the responses and after-effects in the central nervous system of a healthy subject during and after a course of carbon dioxide and hydrogen sulfide baths. Nevertheless a study of these processes is important in order to establish the biological significance of the cutaneous analyzer in contributing to the therapeutic effect produced by the waters.

We have studied the changes in the electrical cortical activity of the cutaneous analyzer and changes in higher nervous activity of dogs during and after a course of carbon dioxide and hydrogen sulfide baths.

#### EXPERIMENTAL METHOD

We carried out 248 long-term experiments in which we recorded the EEG and higher nervous activity (conditioned-reflex salivation); we used baths containing approximately 2g/liter  $\text{CO}_2$  at 36° for 10 min,  $\text{H}_2\text{S}$ -150 mg/liter, 36°, for 10 min. The EEGs were recorded before, during, and after the bath, for 10 min in each case, and the study was continued subsequently for 25-30 days; in order to investigate the after-effects of the baths we measured the indices of higher nervous activity 40 min after each bath.

As positive conditioned stimuli we used a touch-stimulator, a metronome at 120 beats per min, and light; as negative conditioned stimuli we used the metronome at 72 beats per min. As a result of systematic investigations of higher nervous activity we found that 2 dogs out of the 5 could be classified as strong and unbalanced, and 3 as strongly balanced and labile.

The EEGs were recorded from a monopolar lead, the different electrode being placed in the sigmoid or supra-Sylvian gyrus, and were displayed on a 2 KUB-4, MPO-2 oscillograph. The EEG changes were analyzed in terms of variable lability, determination of the change in frequency and amplitude of the dominant oscillatory process, quantities which were deduced from the oscillogram in conjunction with the time marker and the calibrated voltage scale. To make the quantitative data general we used mean or typical values. To analyze the indices of higher nervous activity we used the total secretory component of the conditioned and of the unconditioned feeding reflexes, the latent periods, and differential inhibition. Careful control studies were made.

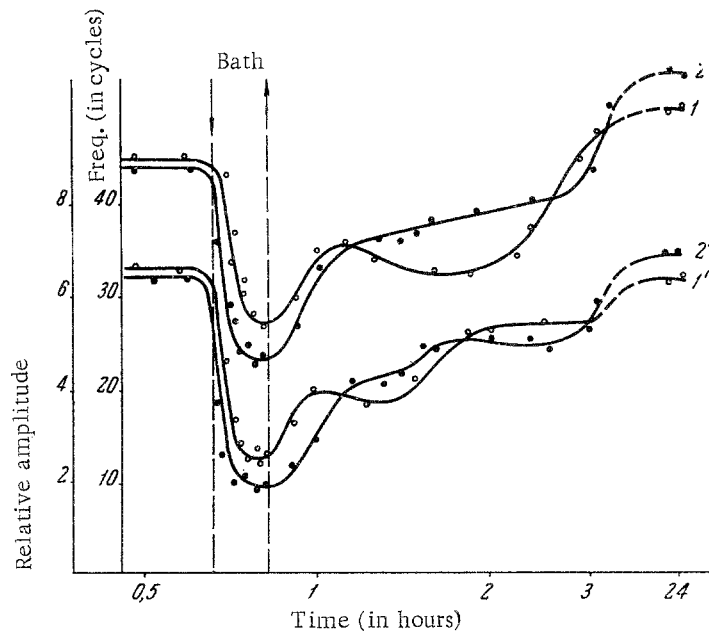


Fig. 1. Change in the parameters of the dominant EEG rhythms of a dog during and after the action of a single carbon dioxide (1-1') and hydrogen sulfide (2-2') bath. Ordinate: 1,2) relative amplitude; 1', 2') frequency (in cycles).

#### EXPERIMENTAL RESULTS

The effect of a single carbon dioxide bath on the animals was to reduce greatly the level of electrical activity in the cortical structures corresponding to the cutaneous analyzer. During the action of the bath there was a further reduction of cortical electrical activity. By the end of the bath the amplitude of the dominant frequency of the EEG had fallen by 38%, and the frequency had changed from 33 to 12 cycles (Fig. 1). In addition to the over-all reduction in the level of cortical electrical activity there was an increase in the amplitude of the high-frequency components. The effect of a single hydrogen sulfide bath was also to bring about a preponderance of the inhibitory process in the cortical structures investigated.

The effect of terminating the mineral bath was to produce after-effects which lasted for many hours; they were both peripheral [1] and central. For the first 2-3 h after the bath the EEG voltage was reduced, the sum-total of the indices of conditioned and unconditioned reflexes was reduced, and there was no change of internal inhibition. Subsequently there was some tendency to an increase in the functional indices. At the end of 24 h after the bath the amplitude of the EEG components reached a level in excess of the initial values; the frequency characteristic of the EEG approximated to normal.

Thus, the effect of a single carbon dioxide or hydrogen sulfide bath was to favor predominance of the inhibitory process in the cortical structures investigated, and to bring about an after-effect consisting of a prolonged inhibition leading on to a phase of exaltation. During the phase of exaltation the next bath was taken, which favored the development of after-effects.

With increase in the number of baths optimal conditions were established favoring the development of interrelated after-effects, processes of temporal summation, of stable and increased cortical electrical activity, and of the indices of the condition of higher nervous activity.

In the second half of the course the functional indices reached their maximum limit. Subsequent baths reinforced the new raised level (Fig. 2).

The effects obtained are to be interpreted as evidence of the nature of the dominant process which is arrested at the exaltation phase the parabolic process.

During the after-effects of carbon dioxide and hydrogen sulfide baths taken for 25-30 days this optimal increase in the level of the functional indices was steadily maintained; subsequently the indices studied tended to return to their original values; the level of the unconditioned feeding reflexes remained enhanced.

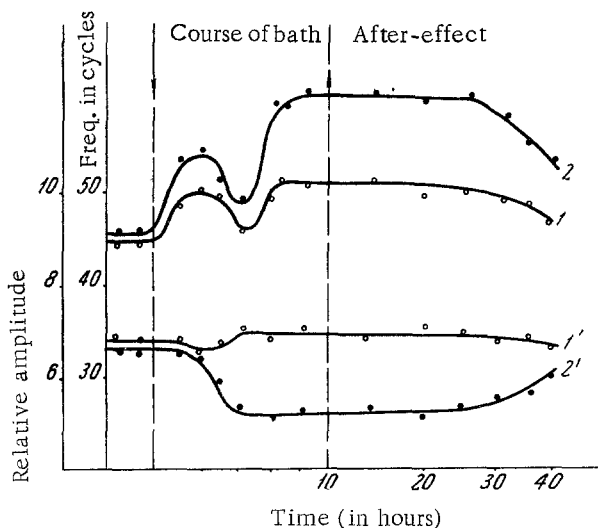


Fig. 2. Change in the parameters of the dominant EEG rhythms of a dog before, during, and after a course of carbon dioxide (1-1') and hydrogen sulfide (2-2') baths. Indications as in Fig. 1.

able increase, by a reduction of the EEG frequencies, and by an increase in the conditioned and unconditioned feeding reflexes, as well as by an increased concentration of the process of internal inhibition.

A comparison of the changes undergone by the indices representing higher nervous activity in response to the action of these baths was related to typological features of the nervous system as follows: during the time the baths were taken the increase in the level of conditioned and unconditioned reflexes was more marked in animals with the strong balanced type of nervous system than it was in those of the strong unbalanced type. The increase in internal inhibition was greater in animals of the strong unbalanced type. The observed functional reorganization of cortical activity occurring after the course of hydrogen sulfide baths was maintained longer in animals of the strong unbalanced type.

The increase in the level of the conditioned and unconditioned reflexes and disinhibition of differentiation, as was observed when the carbon dioxide baths were taken was more marked and more prolonged in animals of the strong unbalanced type than it was in those of the strong type with labile and balanced nervous processes.

Thus, when carbon dioxide baths were taken the increase in the level of the functional indices was associated with disinhibition of differentiation, whereas in the hydrogen sulfide baths the increase of these indices was associated with a reduction in the frequency of the dominant EEG rhythms and with an increase in the concentration of internal inhibition.

A theoretical analysis of the data obtained indicates that during a course of carbon dioxide or hydrogen sulfide baths a central co-ordination develops and is related to features of the dominant process. The maintained optimal level of central nervous function was a feature of the after-effects, of the phenomena of summation, and of the dominant process, as was shown by the profound functional association between the phenomena we have described. The biological significance of these facts is that the system of cutaneous analyzers plays an extremely important part in mediating the therapeutic effects of the bath.

## SUMMARY

Long-term experiments were carried out on dogs. The action of a single carbon dioxide or hydrogen sulfide bath produced a reduction in electrical activity of the cortical area representing the skin analyzer.

The after-effects of the bath was to produce a prolonged inhibitory trace which passed into a phase of excitation; the next part of the course produced effects which were superimposed upon the previous ones. Whether carbon dioxide or hydrogen sulfide was used, a qualitatively new stable increased functional level of the CNS was attained,

We may also pause to consider the special features of the action of carbon dioxide and hydrogen sulfide baths on the organism.

The specificity of the action of these baths shows up when the indices which we investigated are compared. The hydrogen sulfide bath produced greater functional changes in the after-effects; during the after-effects there was a more prolonged and more profound inhibitory residue, which was followed by a change into the phase of exaltation.

When carbon dioxide baths were used the increase in the amplitude and frequency characteristics of the EEG oscillations and of the secretory component of the conditioned and unconditioned feeding reflexes changed over in the middle of the course so that these indices became reduced, and by the end of the course there was a maintained increase and disinhibition of differentiation. However, during the course of hydrogen sulfide baths the initial increase in the amplitude of the dominant EEG rhythms was followed by a fall, and by an increase in the secretory component of the conditioned and unconditioned feeding reflexes; by the end of the course the moderate decrease of the indices observed half-way through it was followed by a consider-

and was maintained during the period of the after-effects. The increase in optimal level applied to the after-effects, to the time of summation, and to the characteristics of the dominant process in which a profound functional relationship between the different phenomena was made manifest. The biological significance of the results obtained is that the dominant role in the therapeutic effect produced by the bath is due to the action of the cutaneous analyzer system.

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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.

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