# EFFECT OF BODY COOLING ON THE MICROPHONE EFFECT OF THE COCHLEA

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According to the data in literature, ice cooling of the cochlea of animals [4, 7] and general cooling of the organism in the presence of subacute ischemic hypoxia [7] produces a distortion of the sinusoidal form of the electric potentials of the cochlea and reduction of their magnitude up to complete disappearance. Warming of the labyrinth increases the intensity of the electric reaction [6] and raises the upper limit of the received sonal frequencies [5].

The aim of our work was to study the effect of general cooling of the organism as well as certain forms of local cooling on the function of the internal ear via determination of the electric reaction (microphone effect) of the cochlea which, as is known, represents one of the indexes of the auditory function of the internal ear.

## METHOD OF EXPERIMENTS

Rabbits of the chinchilla species, aged 6 months to two years, were operated upon under barbamyl narcosis in order to approach the cochlear foramen ovale—the point of best manifestation of the electric reaction of the auditory reception apparatus. The functioning parts of the middle ear and labyrinth were left intact. We recorded the electric potentials of the cochlear action which were carried off from the foramen ovale upon stimulation of the auditory apparatus with pure sounds. The sonar vibrations of needed frequency and intensity were generated by an audiometric device consisting of type ZG-10 generator which had been provided with an attenuator, and an electrodynamic reproductor from which they were relayed via sound-transmitter to the animal's ear. The action potentials were carried off by platinum electrodes, one mm in diameter. The active electrode was attached near the oval foramen, and the indifferent, needle-shaped electrode was inserted in the muscle at the edge of the surgical wound. Recording of the electric potentials was made with a cathode ray oscilloscope of the EO-7 type (for visual observation of the electric reactions) and with a simultaneously cut-in oscillograph-spectrometer with a high frequency photokymocamera (for the recording of electric potentials on the cinefilm at the rate of movement equalling 130-160 cm per second).

A total of 25 experiments were conducted on 19 rabbits. In order to ascertain the effect of general cooling of the body on the microphone effect of the cochlea (11 tests on eight rabbits), we determined the range of received sounds, the voltage of the cochlear potentials upon stimulation with tones of above-threshold uniform intensity—70 decibels (over the 0.000204 bar level), and the liminal magnitudes of the tone intensities which stimulated a minimal electric cochlear reaction at frequencies: 100, 200, 500, 1000, 2000, 3000, 4000, 6000, 8000, 10,000, 12,000, 14,000, and 16,000 oscillations per second. These measurements were taken prior to general cooling, in the state of hypothermia (rectal temperature 25°-26°), as well as (in seven tests) after warming the animals to the initial body temperature. The hypothermia state was obtained by covering the exposed surface of the animal with ice.

In order to elucidate the effect of local cooling on the cochlear microphone phenomenon (14 tests on 11 rabbits) we made similar determinations of the electric reaction as in tests with the study of general hypothermia – during the transitory (for a period of 10 seconds) local cooling, then directly after its cessation, and up to the moment of restoration of the initial temperature of the tissues of external auditory canal, ear drum, and the external wall of the labyrinth. Measurements of the temperature of these tissues were made with an electrothermometer. Cooling was produced via introduction of ethyl chloride or a piece of ice either in the external auditory canal or (for direct cooling of the labyrinth) into the middle ear cavity (bulla tympani) through a trepanation opening in its outside wall. The possibility of a mechanical obstruction to the vibratory movements of the ear drum was excluded because ethyl chloride rapidly evaporated, and the water formed from melting ice was quickly removed prior to recording.

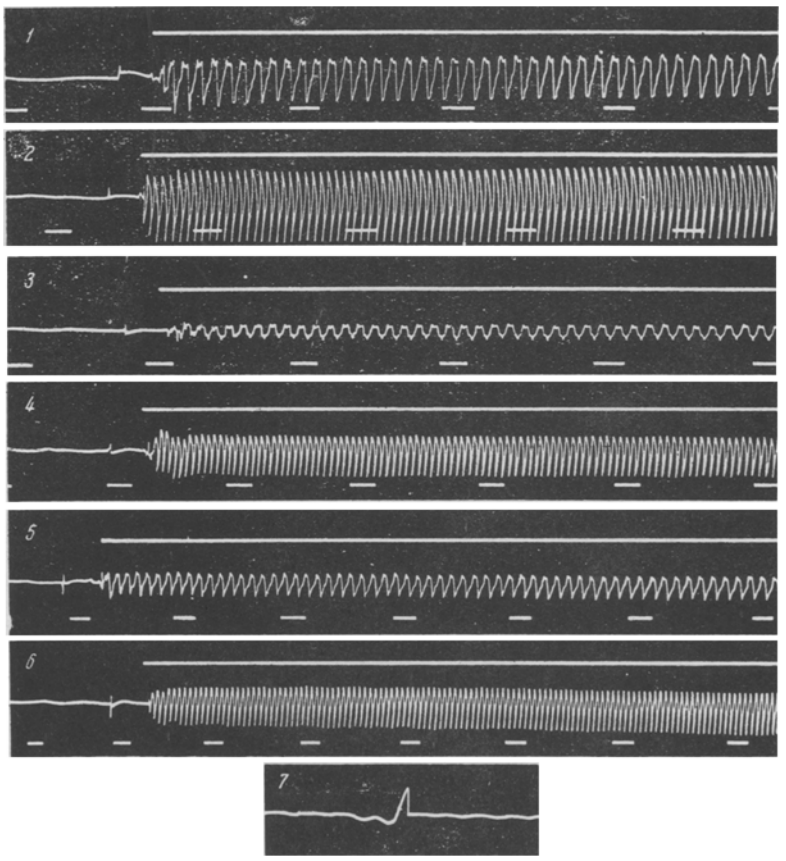


Fig. 1. Oscillograms of electric potentials of the cochlear reaction of a rabbit (experiment No. 8) recorded prior to total cooling of the animal, as well as in the state of hypothermia and after warming. Stimulation of the auditory apparatus with pure sounds, 500 and 1,000 vibrations per second, respectively. 1 and 2) Prior to cooling (rectal temperature 37.5°); 3 and 4) the same, in the state of hypothermia (rectal temperature 25.5°); 5 and 6) the same after restoration of the temperature to the initial level; 7) standard impulse (500 μV). Designation of curves (top to bottom): stimulation mark; time mark (20 msec). To read from left to right.

## RESULTS OF EXPERIMENTS

In rabbits subjected to total cooling the range of received sounds which were responsible for the stimulation of the cochlear electric reaction did not change substantially. However, the magnitude of the electric reaction

(voltage of the potentials) of the cochlea, upon its stimulation with sounds of supraliminal intensity, decreased (with some exceptions), the thresholds of origin of this reaction rose, while the sinusoidal form of the electric potentials became distorted. At some frequencies in several tests, the reaction intensity rose or remained unchanged and the thresholds of its origin decreased or showed no change. Quite frequently we were unable to note any correlation between changes in the magnitude of the electric reaction, following stimulation with sounds of supraliminal intensity (70 decibels), and the direction of liminal changes of the origin of this reaction. At times we observed paradoxical relations, where the reaction intensity would decrease, while the thresholds of its origin would decrease somewhat or would not change at all, and sometimes a reverse relationship emerged. The extent of changes of the intensity of the electric reaction and its threshold of origin in various animals at the same degree of hypothermia differed.

An identical reduction of the temperature may exert a different effect on the electric reaction of the cochlea not only in various animals, but even in response to sonar stimuli of varying frequency in the same animal. Apparently, in hypothermia a change takes place in the reflex influences which may exert a varying, "mosaic" effect on diverse cochlear receptor structures which receive various sonar frequencies. This corresponds with our data, obtained earlier [2, 3], on the "mosaic" character of the reflex regulation of the functional state of the sonar receptor apparatus.

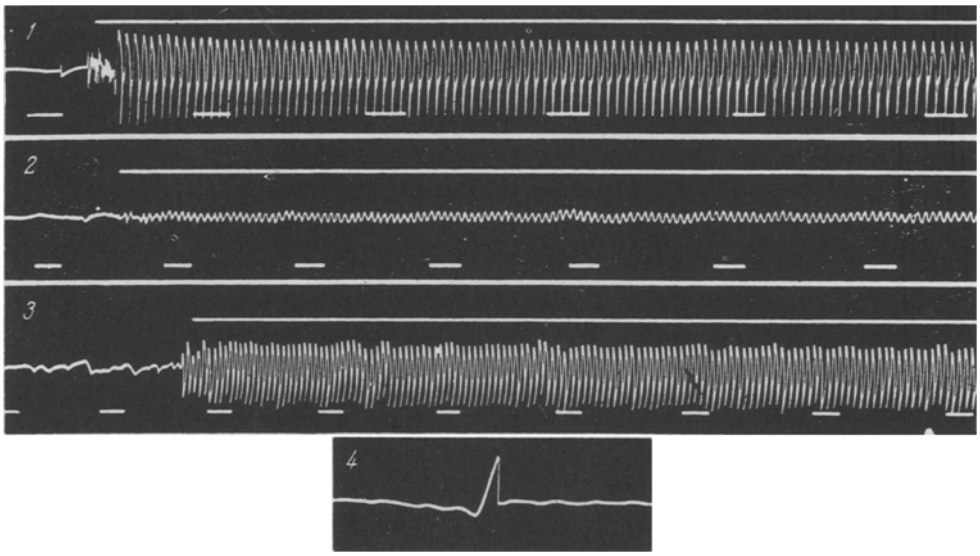


Fig. 2. Oscillograms of electric potentials of the cochlear reaction of a rabbit (experiment No. 19) recorded prior to cooling of the external auditory canal and ear drum, and after their brief (10 seconds) cooling with ice. Upon stimulation of the auditory apparatus with a pure sound of 1,000 vibrations per second [temperature of the external wall of the labyrinth (promontorium) 35°]. 1) Prior to cooling; 2) the same within 10 minutes after cessation of cooling (temperature of the external wall of the labyrinth 34.9°); 3) the same within $3\frac{1}{2}$ hours after cessation of cooling; 4) standard impulse (500 $\mu$V). Designations the same as in Fig. 1.

At the moment of restoration of the body temperature (by warming) to its initial level, no complete restoration of intensity of the cochlear electric reaction and the thresholds of its origin would necessarily take place in each case; considerably more frequently the restoration was incomplete (Fig. 1). At times, no restoration took place at all; moreover, upon stimulation with certain frequencies, a further reduction of the reaction intensity and increase of the thresholds of its origin was observed.

Restoration of the reaction intensity, upon stimulation with sounds of supraliminal intensity (70 decibels), often did not correspond to the direction of changes of the thresholds of its origin.

Apparently, in hypothermia fairly stable changes may take place, since at the moment of temperature restoration to the initial level no complete restoration of the functional state of the cochlear receptor structures which generate electric potentials had taken place in the overwhelming majority of cases.

A local brief (10 seconds) cooling of the external auditory canal and ear drum with ethyl chloride or ice rapidly caused a considerable narrowing of the band of sonar receptor frequencies (at the expense of reduction of the upper and increase of the lower limit), as well as a sharp reduction in the intensity of the cochlear electric reaction at all average frequencies. In case of average frequencies, the disappearance of the reaction could be observed only upon more prolonged cooling.

After the restoration of local cooling, the cochlear electric reaction again began to increase as manifested in the form of a gradual widening of the band of sonar frequencies which started the reaction (at the expense of the successive rise of the upper and lower threshold), and the voltage increase of the action electro-potentials (Fig. 2). A full restoration of the reaction (to the initial level) took place within $3\frac{1}{2}$-4 hours after the cessation of local cooling.

Upon a direct and brief cooling of the labyrinth via introduction of ethyl chloride into bulla tympani, the cochlear electric reaction changed to the same extent as upon cooling of the external auditory canal and ear drum, but it was more rapid.

It was found that in local brief cooling the electric reaction changes had not been caused by the reduction of the temperature of the cooled tissues, as attested by the results of measurements of their temperature immediately after the removal of the cooling substance. Thus, in nine tests out of 14 the temperature of tissues showed no change, and in the rest it decreased only by a fraction of a degree and was restored within a few minutes after the removal of the cooling substance. These data basically correspond to the results of investigations by other authors [1]. We may, therefore, assume that the considerable and fairly protracted changes of the microphone effect which had taken place after a brief local cooling were caused by reflex influences originating upon cold-stimulation of the receptors of the ear drum, tissues of the external auditory canal, or the mucous membrane of the middle ear cavity. As a result, there was a rapid change in the functional condition of the cochlear receptor devices which generate the electric potential, the change lasting a fairly long period of time ($3\frac{1}{2}$-4 hours). The non-uniform effect of these influences at various sonar frequencies also corresponds to the "mosaic" character of the reflex regulation of the functional state of the cochlear receptor devices.

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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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