SOME PHYSIOLOGICAL SPEECH PROBLEMS IN HIPERBARIA

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Economical conditions and the developement of our civilisation draw our attention to scientific researches of the undersea world and to its industrial exploitation. Apart from many technical and physiological problems one of the most virtual is to assure the diver a good verbal communication during his work in gas-hiperbaria. The researches of Hollywell and Harvey (2), Mac Lean (5) and Golden (1) concerned only acoustical analysis of divers speech in helium-oxygen mixtures. The aim of this report is to demonstrate the results of our investigations on speech in air-hiperbaria. Investigations performed on the physiology, pathology and acoustics of a divers voice in air overpressure we described in a separate paper (3). Common rules formulated in our works could be extrapolated to different gas mixtures, taking into account their specifics. Specifics of various languages must be also considered.

MATERIAL AND METHODS

The investigations were performed with 20 young, healthy, professional Polish sea-divers, who are phoniatricaly correct. The text used for the investigations was: "głosem dźwięczącym" which means: "with sonorous voice". The divers staying in the pressure chamber read the text (recorded on the magnetic tape AGFA) at pressure levels: normal, 1, 2, 3, 4, 5 and 6 atm. gage pressure. They were trained to read the sentence properly and to maintain a steady level of loudness, which was also checked on the level meter. The tape recorder was provided with capacity Brüel-Kjaer type 4133 microphone. The frequency range of the tape recorder was from 20 Hz to 18 kHz. The pressure chamber had a good acoustical characteristics and the reverberation measurements, carried out at various pressure levels, enabled us to eliminate its influence on the acoustic structure of recorded speech. Acoustical analysis of the text was performed using the Key Electric "Sonagraph". May I express, just now, my heartiest thanks to Prof. Dr. Sc. M. Seeman, Head of the Phoniatric Clinic in Prague and m.d. A. Novák for their willingness and valuable advices, as well as for enabling me to use the instrument.

RESULTS

The tested text consists of vowels and consonants, mouth and nasal sounds. The sonagrams were evaluated on ground of direct observations and measurements of the formant bands using a photoelectric transducer. The frequency bands of sonograph filters were 300 Hz. The acoustic structure of the tested text and the time parameters at different pressure levels were compared using the "t" Student's test.

Depending on the pressure in the chamber we stated: 1. increase, damping or decay of some frequencies, 2. translocation of the formant bands into higher frequencies, 3. occurence of a formant band in the range at about 4—5 kHz and increase of this range of nasal sounds. It is bound with the insufficiency of the soft palate, which causes the increase of the nasal resonance, 4. shape changes of some formant bands, 5. decay of slit sounds such as s, c, cz. It involves lacks in the text and changes its logical structure, 6. elongation of the phonation time of the text from 1,55 sec. (δ = = 0,09) average to 2,05 sec. (δ = 0,13) average. All these changes were bounded with the mechanical influence of air-hiperbaria on the voice organ and the narcotic effect of air-hiperbaria on the central nervous system of the diver and on his hearing process (4). The stated changes were statistically significant ($p < 0,01$). A sample of an acoustical analysis of the text read out by one diver in normal air pressure and 6 atm. gage pressure is given bellow on fig. 1 and 2.

The text: "głosem dźwięczącym" at normal air pressure, according to Boltzmann's formula (6), has the entropy of 1,2041 d.u. average per stimulus. But at 6 atm. gage pressure the average information content, according to Shannon's formula (6) diminishes to 1,079 d.u. average per stimulus. The average information content of the text read out by 20 divers, with regard to sounds, lowered statistically significantly ($p > 0,01$). The additional factors which increase the desinformation is the change of the timbre and the pitch of the sounds and a lengshening of the phonation time. Generally the speech of divers in air-hiperbaria is slow, high pitched and nasal. The changes in the information content of speech in air hiperbaria, in which also other factors affect the diver (e.g. emotion, the influence of breathing noises etc.), lead to desinformation and to errors in submarine operations which could end tragically. Because in few cases the intelligibility of speech was good, it seems that suitable persons for proper phonation in hiperbaria should be selected using tests. By training of the vocal organ some divers could be also adapted to such conditions.

CONCLUSIONS

1. The specific influence of air-hiperbaria on the central speech analyser and the peripheral speech organ involves changes in the acoustical structure of divers' speech and is the reason for disturbances in its information content.
2. Apart from the vocoder correction of speech in hiperbaria, phoniatric training should be introduced to adapt the speech organ of divers to work-conditions in hiperbaria.

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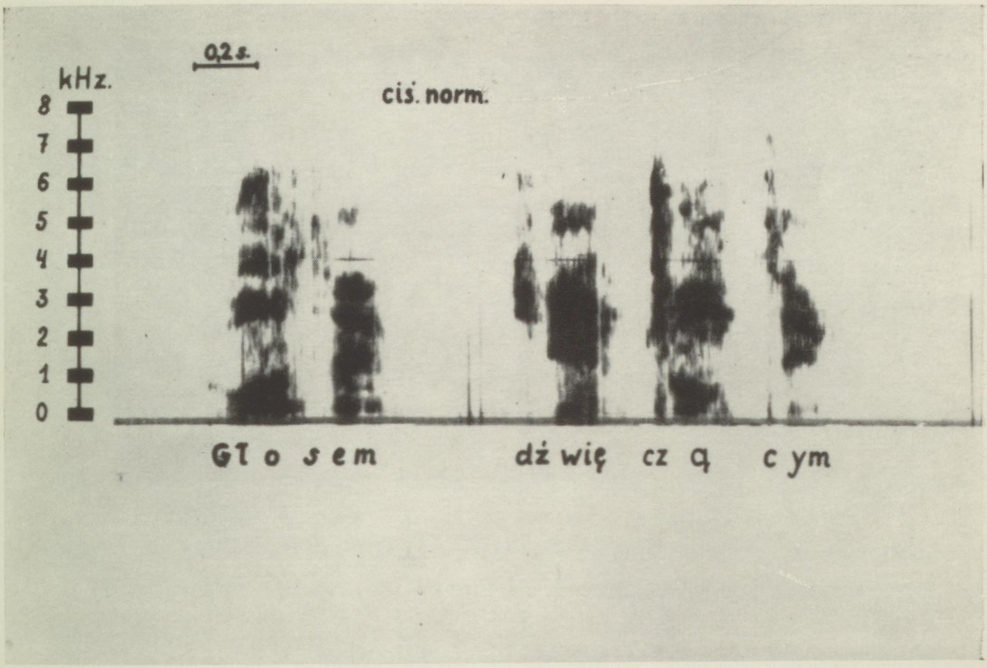
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Fig. 1.

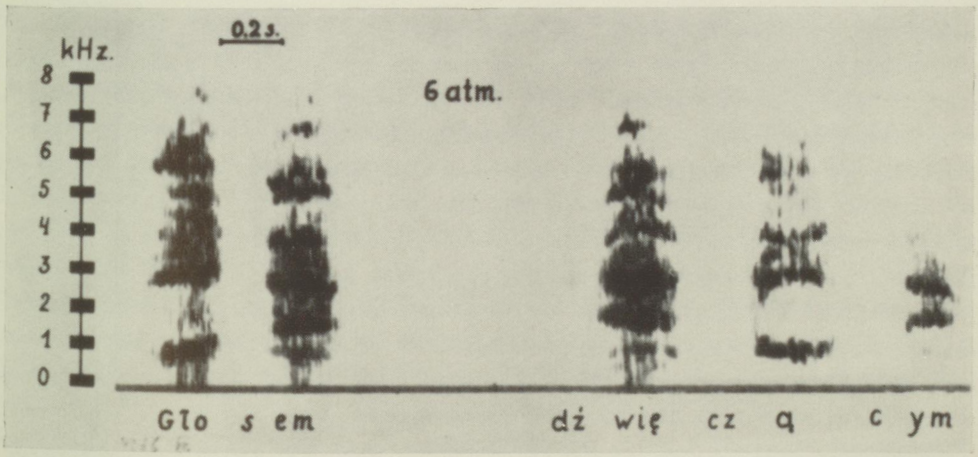
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Fig. 2.