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ASSESSMENT OF THE MASKING EFFECT OF NOISE ON CHANGES IN HEART RATE VARIABILITY ANALYSIS INDICES

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Summary. The changes in the indices of heart rate variability analysis (HRVA) at deteriorated speech communication, S/N – 10 dB(A) and S/N – 20 dB(A), are investigated. The significant difference in the mean values of HRVA demonstrates the possibility of using them in assessing nervous-emotional strain. There is evidence of a definite „physiological cost" of the masking noise (read by HRVA), attributable to discrimination of the useful signal from masking noise.

The indices of heart rate variability analysis (HRVA) are more sensitive to the time shortage feeling, accompanying information processing, than to the information processing proper. Many years researches by the authors [5] have [illegible] there are tasks and production activities where difficulties faced during information processing are the underlying cause of the work stress resulting, rather than the shortage of time for the processing proper. It is a matter of tasks where the functional stress of performance is produced by the unfavourable signal/noise correlation. One of the optimally clarified and thoroughly studied models of such type of working activity is the masking effect exerted by noise on occupationally relevant speech information. Proceeding from this model, a great number of experimental researches along this line have been carried out over the past 25 years [4, 5]. The model is applicable in both laboratory and production conditions, and in our opinion, it is likewise representative in terms of any type of information processing, taking place in conditions of detrimental signal/noise correlation, not infrequently met with in practice. For this reason, it was used to evaluate the information relevance of the HRVA indices in the conditions outlined. Here the physiological phenomena underlying the masking effect of noise are not dealt with because they have been aptly described by various authors [2, 4, 5, 6, 7].

It has been established [3, 4, 5] that differing in type industrial noise masks in a varying degree the speech signals, insofar as the noise noxa impairs both the functional efficiency of the auditory analyzer, and speech communication.

Whether or not speech communication impairment is linked to changes in certain physiological parameters is an issue still not well enough clarified. Such changes may be tentatively coined with the term „physiological cost" of noise masking. As shown by studies, conducted in the State Enterprise „Kremikovtsi", there is a rather large number of working posts characterized by obvious failures regarding adequate perception of speech information. This in turn, adds to the importance of the problem and to the necessity to obtain a precise solution.

MATERIAL AND EXPERIMENTAL SETUP

The investigation was performed in a special noise-isolated room. Using a stereo-tape-recorder and loudspeakers the following signals were fed: a) useful signal – speech audiometric test of L. Tsaneva (SAT) containing professional terminology and intensity L equiv 87 dB(A) (condition I), and L equiv 77 dB(A) (condition II), and b) broadband impulsed noise at intensity L equiv 97 dB(A), recorded in the pipe-rolling shop of Kremikovtsi. In condition I setting the ratio between useful signal and noise (S/N ratio) amounted to 10 dB(A), and in condition II – 20 dB(A). At the latter ratios it was expected that intelligibility of the useful signal would amount to 86 per cent for condition I, and 44 per cent for condition II, respectively, according to the authors' nomogram [4, 5]. These values met three indispensable requirements between the two conditions, namely: presence of a substantial difference in intelligibility; in condition I it should never reach 100 per cent, insofar as this would increase the role played by extratest factors; in condition II it should not be too low since this would reduce the motivation of the subjects experimented upon.

Twelve men and twelve women (students), highly motivated and fully aware of the task undertaken, with previous experience in experiments of the kind, were subjected to repeated investigation (twice).

The task of the subjects being tested consisted in reporting on the microphone a series of SAT words fed to them. The answers were transmitted telemetrically by means of a Medicor system, registered, and subsequently processed for omissions, right and wrong perception and number of signals (words) reproduced. The two task conditions were fed at random. Recording of the anacrotic and catacrotic wave of plethysmogram was done by pulse rate tachometer and writing device after the method of Danev (1989).

Reciprocal positioning of the noise source and useful signal in the chamber, established in earlier researches, was optimal.

HRVA indices were calculated from 10-minute epoches for each individual and each condition. The order of feeding the conditions was fortuitous. All subjects underwent preliminary examination by threshold and supraliminal auditory tests for eventual presence of pathological changes in the auditory analyzer, with adjustment according to Efrusi. The time interval between the odd words being fed was 6 seconds average which was sufficient to eliminate the time shortage feeling (TSF). It varied in the range 5 to 7 seconds at random to avoid the rhythmic heart rate effects, generated by the pace of the task.

RESULTS AND DISCUSSION

The obtained results are presented in Table 1.

Table 1. HRVA Indices at Either Level of the Masking Effect of Noise (12 men and 12 women with mean age 22.2 years)

Indicator	Condition I L equiv 10 dB(A)			Condition II L equiv 20 dB(A)	
	$\bar{X}$	Sx	t-test	$\bar{X}$	Sx
HRVA indices in group one					
$\bar{X}$	866	106	++	698	94
SD	51.4	22.5	0.03	38	19.3
V_1	9.9	4.1	0.68	9.3	5.8
S	254	49.6	++	141	31.4
HRVA indices in group two					
Mo	858	115	++	682	86.8
AMo	19.7	2.6	0.03	21.5	3.1
SI	209	78	++	145	71.0
VRI	55	17.8	++	108	27.8
VBI	2.11	0.43	++	5.57	1.9
HI	0.44	0.21	++	0.83	0.39
HRVA indices in group three (HRSF)					
	26.0	5.9	++	34.0	7.3
Rbp	37.0	7.3	++	29.0	4.9
Rr	28.5	4.3	0.01	24.5	6.1
SAI	0.70	0.29	++	1.17	0.21
Pbp	11.0	3.0	++	7.3	2.4
A 0.1	4.3	1.13	++	2.6	0.81
KI_1	0.56	0.22	++	0.38	0.17
KI_2	4.3	1.7	++	2.1	0.50

On comparative assessment of the two signal/noise ratios (S/N) – L equiv 10 dB(A) and L equiv 20 dB(A) – it was established that condition II was characterized by the following findings:

a) In the variability indices of cardiointervals (group one) there was a statistically significant decrease in the mean values of cardiointervals ($\bar{X}$), standard deviation of cardiointervals (SD), and in the sum of all positive differences between two adjacent cardiointervals (S).

b) In the HRVA indices of group two, linked to the distribution of cardiointervals, a statistically significant reduction of Mo and strain index (SI), and a statistically significant increase in the amplitude of mode (AMo), vegetative rhythm indicator (VRI), vegetative balance indicator (VBI) and homeostatic index were documented.

c) In the HRVA indices, linked to the frequential spectrum of heart rate (HRFS) (group three), a statistically significant increase was registered in the subcortex activation index (SAI) and integral power of the II order slow waves of thermoregulation (Rt); the rest of indicators, namely: integral power (of slow waves I order for blood pressure (Rbp), integral power in the region of respiratory sinus arrhythmia (Rr), period of waves linked to blood pressure (Pbp), amplitude in the region 0.1 Hz/A 0.1, ratio of integral power in the zone of supralong waves to the wave period linked to blood pressure (KI_1), and difference in amplitudes of the frequential spectrum of cardiointervals, linked to blood pressure oscillations and those related to respirations (KI_2) disclosed a statistically significant reduction.

The significant difference in mean values of most of the HRVA indices demonstrates the possibility of their utilization in assaying nervous-emotional strain in this particular type of occupational tasks. Presumably, there exists a definite „physiological cost" of the masking noise (read by HRVA) that should be borne in mind upon assessment of the severity of the various types of activities giving rise to nervous-emotional strain, generated in turn by the discrimination of the useful signal from the masking noise. This is further corroborated by the mean values of the anacrotic wave amplitude, amounting to 25.48 mm in condition I, and 18.85 mm in condition II ($p<0.009$) according to Student's t-test for dependent variables.

The total number of oversights and errors in either of the conditions was 12.2 per cent for condition I and 54.7 per cent for condition II which is consistent with the preliminary requirements. No differences in the performance of individual persons, worthy of notice, were established.

As shown by the analysis results, in the event of speech-information processing difficulties against the background of exposure to the effect of intense industrial production noise, characteristic changes in the HRVA indices are noted which may be coined with the term „psychophysiological cost" of the masking noise. The experiment performed proves the existence of the latter, and estimates approximatively its magnitude in the specific case of S/N – 10 dB(A), and S/N – 20 dB(A). The psychophysiological „cost" differs from the changes occurring as the result of direct exposure to noise. The underlying cause of its manifestation are difficulties in semantic perception, produced by the intensive noise. Its effect under occupational conditions is added to the one exerted other factors relating to the concrete working activity, and in this fashion the allowable limit of psychophysiological changes in the operators' organism during work is exceeded.

CONCLUSIONS

The considerable experimental material accumulated justifies a number of theoretical generalizations and conclusions without which thorough solution of the problem and its clarification would be impossible, such as: the quality of heart rhythm assumed as the first signal of changes in vegetative status, effector of the most important unit forming the adaptation response, mirroring all changes in the homeo– and heterophasic balance, the basic „payment bill" in paying off the „physiological cost", inadequate adaptation to dynamic changes in the external and internal milieu of the organism, accordingly to the masking effect of noise.

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