Long-term Exposure of Working Persons to Low Frequency Noise

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Exposure room

The infrasound exposure room was planned to accomodate one or two test persons for some hours. It had a volume of 14 m^3 and one window(1). One wall was covered with 24 low-frequency loudspeakers which were supplied from a 250 W output amplifier. The loudspeakers were stimulated below their "Eigenfrequency", and produced in that frequency area a homogenous pressure field independent of the frequency.

Hypothesis and methods

In this room, the influence of infrasound on the people staying there for up to 8 hours was examined. As suggested by literature on infrasound the authors originally looked for reactions similar to seasickness (2) and tiredness (3). For further examination of these hypotheses appropriate questions were drawn up in a questionnaire. In addition to this, electromyogram (EMG) and electrooculogram (EOG) derivations were made to supply objective data. The integral value of the EMG derived from the neck was chosen to measure the relaxing of the musculer tonus before "nodding-off". As a test for tiredness, a film of approximately 15 minutes in length was shown, and the EOG recorded at the same time. The film had been taken from a moving car. In order to quantify the stress influence of infrasound, ECG recordings were made. From the ECG recordings only the heart frequency was taken. Analysis of the heart frequency was based on the following hypothesis. Heart frequency is a controlled variable which increases with physical performance. Noise does not change the physical performance, and therefore the long-term average of the heart frequency is not influenced. Noise does, however, act as a disturbing factor on the autonomous nervous system which controls the heart frequency, and can therefore possibly enlarge the small existing control variations of the heart frequency. In order to distinguish between control variations and heart frequency changes influenced by physical performance, the change in the heart-rate from pulse to pulse was examined, and from this the heart-rate variation was determined (Fig.1). For analysis of the ECG, trigger-pulses were generated at the peaks of the R-waves, by a device which differentiated the ECG twice. The times between these trigger impulses were transformed into analogous voltages. The differences of the momentary heart-rate from pulse to pulse were calculated, and the probability density of the heart-rate differences ΔT was plotted. Usually $\Delta T = 0$ is the most probable value. The heart-rate variation (HRV) was defined as the width of the ΔT histogram at the height representing 10 % of the maximum value. A questionnaire with 17 questions was to be completed after each test and control session. Each question was answered quantitatively according to a 5-grade scale which was graded as follows:
1) very correct 2) passable 3) indifferent 4) slightly correct 5) not correct.
By these methods 28 test persons, mostly students, were examined which had to perform mental work on self-chosen subjects. Twenty persons were examined under infrasound twice for four hours, and without infrasound also twice for four hours. Eight persons were examined once for eight hours with infrasound, and once for

eight hours without. The spontaneous remarks of the test persons were also recorded.

Results - Subjective findings

Only 5 out of 28 examined test persons felt totally uninfluenced. The other 23 test persons stated most frequently that under infrasound their ability to concentrate lessened (8 times); furthermore, they complained of pressure on the ears (5 times), disturbance due to vibration (3 times), and increasing tension (3 times) during the session, and the feeling of increasing tiredness (7 times) and tension (4 times) at the end of the session. In two cases temporary mild giddiness occurred when watching the traffic film under infrasound. It was remarkable that some of the test persons who had felt well during and shortly after the session complained of headache (twice), giddiness (twice), and physical depression (twice) the next day, beginning approximately one to four hours after the end of the infrasound session. The subjective results of the questionnaires from 28 test persons at 96 test sessions is shown in the list, where $\overline{\Delta}$ means the mean difference of the answers given by the test persons after infrasound and control sessions, respectively. The signs were chosen so that a harassing infrasound influence would be represented by a positive $\overline{\Delta}$. In the last column of the list, the probability of error p as determined by the t-test shows whether the calculated $\overline{\Delta}$ values are accidental results or significant consequences due to infrasound.

Statement	$\overline{\Delta}$	p	Statement	$\overline{\Delta}$	p
learning is more difficult than usual	1.4	0.001	I am attentive	0.6	0.01
I need rest	0.8	0.001	I feel well	0.6	0.01
I am satisfied with the working conditions	0.8	0.01	I feel listless	0.5	0.05
I feel disturbed	0.75	0.05	I am exhausted	0.4	0.05
I need relaxation	0.7	0.001	I am slightly dazed	0.4	--
I am uninfluenced	0.7	0.01	I am wide awake	0.3	--
I feel bothered	0.7	0.05	I am annoyed	0.2	--
I feel relaxed	0.6	0.001	I am giddy	0.1	--
			I am sleepy	0.05	--

The subjective results can be summarized as follows:

The ability to learn was most affected by infrasound.

In the second place were the harassing and exhausting effects of infrasound.

The results indicated a slight influence on the mood, although infrasound did not lead to bad temper.

The original hypotheses, according to which infrasound should lead to an unwell feeling and tiredness, could not be confirmed by the results of the questionnaires.

It should be mentioned that two kinds of tiredness must be distinguished a) tiredness caused by exhaustion, b) tiredness caused by monotony, lack of oxygen etc. Our results show that only the first kind of tiredness may have been caused by infrasound. When calculating the mean values of the differences δ for each person, with and without infrasound for all 12 statements with $p < 0.05$ it is possible to find the percentage of test persons influenced by infrasound. In the histogram (Fig. 2) the area with diagonal hatching represents the affected test persons.

The infrasound exposure chosen (110 dB, 12.5 Hz 1/3 octave band noise) affected 50 % of the test persons.

Objective findings

Tiredness caused by infrasound effects other then exhaustion could not be confirmed by the above-mentioned objective criteria. Neither the EOG integral values over the film periods, nor the EMG integral values were systematically influenced by infrasound of up to eight hours' duration. In contrast to these parameters it was found that the HRV was a stress parameter sensitive enough to reflect the small alterations due to additional infrasound. In Fig. 3, the distribution of the relative HRV changes in all test persons during the sessions with and without infrasound is shown. From all sessions, the periods during the last film were evaluated with the setup described in Fig. 1.

Taking into account all test persons, the mean value of Δ HRV is $\overline{\Delta \text{ HRV}}$ = 9 %. This result is not statistically significant. Considering only that half of the test persons who were subjectively influenced by infrasound (Fig. 2, right area), the relative increase of HRV due to infrasound $\overline{\Delta \text{ HRV}}$ = 15 % ($p < 0.01$).

References:

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(3) R.FECCI, R.BARTHELEMY, J. BOURGOIN, A. MATHIAS, H. EBERLE, MANTEL, A., G. JULLIEN Med. Lavoro 62, 130-150 (1971).

Heart Rate Variation

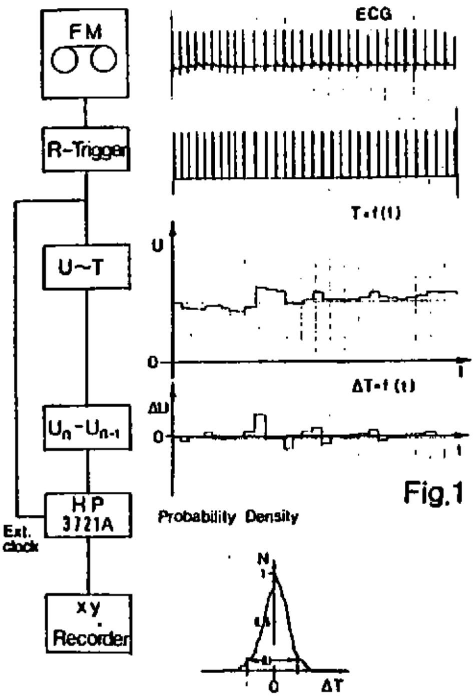

Fig.1

$HRV = \Delta T_{10\%}$

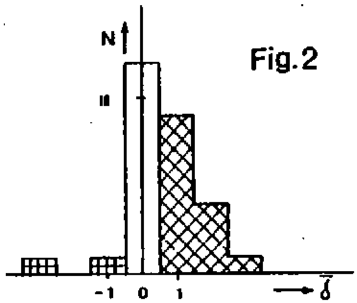

Fig.2

Distribution of the meanvalues of questionnaire-scaling-differences $\bar{\delta}$ with and without Infrasound

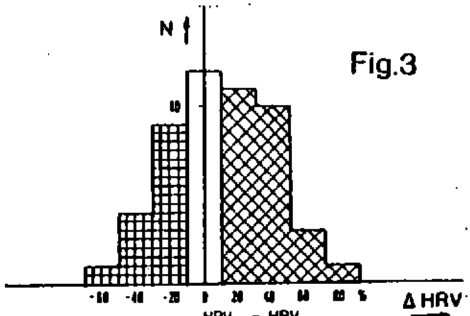

Fig.3

Distribution of $\Delta HRV = \frac{HRV_{inf} - HRV_{control}}{HRV_{control}} \cdot 100\,\%$