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MEASUREMENTS AND ANALYSES OF TEMPORAL VARIATIONS IN NOISE AND THE RELATION TO NOISE ANNOYANCE

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1.INTRODUCTION

One of the factors presumed to have a great influence on noise annoyance in working environments is intermittence. According to the literature (e.g. [1, 2]) rather extent research has been carried out on intermittent noise. However, the definition of intermittence has generally been implied and imprecise. In ISO 2204 [3] a definition is given which includes a lower limit of duration of the sound events of the order of magnitude of 1 s or more.

Laboratory experiments have shown that intermittent noise results in increased noise annoyance ratings [4]. Moreover, the occurrence of temporal variations in a wider sense than intermittence has been found to increase annoyance [5, 6]. Temporal variations in a wider sense have been studied at duration times from impulses to traffic noise events. It is therefore of great importance to take the temporal variations into account when assessing noise below hearing damaging level in working environments. However, there are few studies of temporal variations and their effects during work.

This paper describes an analysis of different temporal variations of noise measured in working environments and its relation to rated annoyance. A possible effect of work task is also discussed.

2.MATERIAL AND METHOD

All together 338 participants were recruited from various work environments at 23 different work places. They represented different types of noise environments where the sound level was below 85 dB(A).

A microphone was placed adjacent to the participant's workplace. The noise was recorded during a period of about 15 minutes, during which the participant worked normally. Noise annoyance during the measurement period was rated on a 100 mm scale (fig. 1). This scale has previously been used in work place and laboratory studies [4, 7]. The scale is improved by a calibration procedure taking the individual scale interpretation into account [8]. Annoyance ratings of recorded pink noise at different levels were used for calibration of the scale in accordance with the method of Master scale transformation [8].

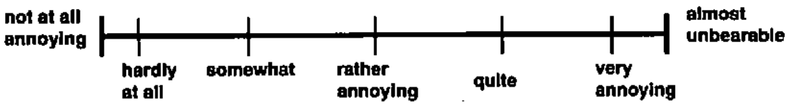

Fig. 1. Noise annoyance rating scale.

The sound level variability is studied by looking at the A-weighted level changes with a specific time constant. Ten minutes out of the recorded fifteen minutes were analysed. The selection of ten minutes was made to allow the participants to habituate to the situation during the first minutes of the recordings. Three different time constants were tested: 0.5, 1 and 2 seconds. An RMS value was determined for each interval of 0.5, 1 or 2 seconds. Then the successive differences between each discrete value were calculated. The differences were counted if being over a magnitude limit. Three magnitude limits were tested: 3, 6 and 9 dB. The analysed ten minutes were divided into periods of 30-seconds and the successive differences were counted in each period. Mean value and standard deviation for the number of differences in the periods were then used as measurements of "variability" (V) and "irregularity" (I) for each recording. These measures were tested by correlating them to the annoyance ratings.
For approximately the same ten minutes an equivalent dB(A)-level was measured. The chosen significance level is 0.05.

3.RESULTS

Initially the different levels of variability (V) and irregularity (I) were tested for their correlation to the rated annoyance. The correlation coefficients (r) for the material are presented in Table 1 and Table 2. For comparison the correlation to the equivalent dB(A)-level is 0.2842.

Table 1. Correlation of variability (V) to annoyance for the three magnitude limits and the three time constants. An asterisk indicates significance at level 0,05.

Magnitude limit	V (0.5 s)	V (1 s)	V (2 s)
3 dB	-0.2263 *	-0.2052 *	-0.2039 *
6 dB	-0.2767 *	-0.2570 *	-0.2315 *
9 dB	-0.2771 *	-0.2725 *	-0.2498 *

Table 2. Correlation of irregularity (I) to annoyance for the three magnitude limits and the three time constants. An asterisk indicates significance at level 0,05.

Magnitude limit	I (0.5 s)	I (1 s)	I (2 s)
3 dB	-0.2192 *	-0.1184 *	-0.0203
6 dB	-0.3126 *	-0.2734 *	-0.1753 *
9 dB	-0.3142 *	-0.3076 *	-0.2533 *

The pattern is the same in both tables. The time constant 0.5 s gives the best correlation. The magnitude limits 6 and 9 dB both give about the same correlation and a better one than with a limit of 3 dB. The middle limit (6 dB) is preferred since it gives a wider range of applicability. In the following, the results obtained using a time constant 0.5 s and a magnitude limit 6 dB are chosen.

Due to the assumption that background levels of noise do affect the annoyance from noise, a classification into different level groups was made. The correlation for these groups are shown in Table 3.

Table 3. Correlation of variability (V), irregularity (I) and dB(A) to rated annoyance for the different level groups. An asterisk indicates significance at level 0,05.

Level group (number)	V (0.5 s)	I (0.5 s)	dB(A)
LeqA < 50 (44)	-0.0705	-0.2841	0.2148
50 <= LeqA < 60 (139)	-0.3181 *	-0.3678 *	0.0771
60 <= LeqA < 70 (109)	-0.2953 *	-0.2853 *	0.1032
70 <= LeqA (46)	-0.0672	-0.0829	0.3297 *

According to Table 3, significant correlations to annoyance appear in the level range of 50 - 70 dB(A).

To find out any differences according to work task the participants were grouped for work environment. Eight main groups were obtained. They are listed and labelled as follows with the size of the group within parenthesis: 1. Offices (110), 2. Dental Workshops (30), 3. Educations/libraries (33), 4. Industries/laundries (53), 5. Laboratories (33), 6. Cash-counters (12), 7. Day-care centres (11) and 8. Manoeuvre rooms (56).

The groups in which verbal communication was important, showed better correlation to rated annoyance than the others. Selecting the three categories 3, 6 and 7 and combining this with an exclusion of participants with equivalent levels below 50 and above 70 dB(A) the correlations showed in Table 4 were achieved.

Table 4. Correlation to rated annoyance for the group of selected categories in the level interval 50 to 70 dB(A)eq. An asterisk indicates significance at level 0,05.

Level group (number)	V (0.5 s)	I (0.5 s)	dB(A)
50 <= LeqA < 70 (46)	-0.3842 *	-0.3729 *	0.1391

4.DISCUSSION

The low correlations obtained in this study supports the idea to study noise annoyance as a multifactorial phenomenon. Especially when dealing with field observations where several non-physical factors probably will interfere. The variability measures yielded correlations to annoyance of about the same size as the equivalent dB(A) level. However, the former correlations were negative, which indicates that rare and evenly distributed level variations under some conditions are especially annoying.
The choice of the different time constants originated in the level variations of interest. Since the definition of intermittence prescribe a time duration of about 1 second or more, that is the lower time limit for this study. The intention was to study variations with a time duration from above impulse sounds. That also implies a time constant around 1 second.
The effect of magnitude criterion for differences indicates that 3 dB, probably is too low and includes the "normal" variations in noise.
The background level may be important but in this case the material is not equally distributed over the level range. Therefore it is hard to say anything about the better correlations in the range of 50 - 70 dB(A).
The classification for work task was made for to study any possible effect on the rated annoyance of noise. In this study the tasks involving speech communication showed a higher correlation to annoyance. A possible explanation may be that level variations of sufficient magnitude and low and regular frequency affect the possibilities to speak in a steady and comfortable way. The effort to keep up an intelligible speech communication may be a cause to the higher correlation to annoyance.
The correlation was also improved when taking into account the overall equivalent dB(A) level. The chosen level range, 50 - 70 dB(A), interfere with the level of normal speech communication.
This study will be followed up by a more proper multifactorial analysis.

5.REFERENCES

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