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Traffic Noise and Annoyance in a Laboratory Condition[1]

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Experiments with subjects showed to which extent acoustical parameters are determinant for the annoyance.

Introduction

The aim of the investigation was to find out a physical noise parameter best adequate to the annoyance caused by road traffic noise. In order to eliminate as many irrelevant factors as possible influencing the exposition situation the investigation was carried out under laboratory conditions.

Method

9 traffic noise situations were recorded on tapes at 3 roads outside town, carrying 125, 500 and 2000 vehicles per hour respectively. Fig. 1 shows one of the recording conditions. At each of the roads the recordings were made at 3 distances: 25, 100 and 300 meters. In this way we obtained 9 tape recordings, each with its special character appropriate to the situation recorded.

Figure 1
One of the recording conditions

TRAFFIC DENSITY (VEHICLES / HOUR)	DISTANCE FROM THE ROAD 25	100	300 M
125 V/H	59	52	47
500 V/H	68	55	50
2000 V/H	73	63	56

Table 1
The 9 noise exposures
Equivalent noise levels in dB(A).

Table 1 shows the 9 noise exposures related to traffic density and to the distances. The values in the squares indicate the noise level of each exposure expressed in the equivalent noise levels. The noise levels increase with traffic density and decrease with distance.

The tape recordings were evaluated in a noise laboratory and we calculated the 4 classical noise parameters and 6 different cumulative frequency noise levels seen below:

ALL PARAMETERS IN dB(A)	ABBREVATION
Equivalent Noise Level	L_{eq}
Noise Pollution Level	L_{np}
Arithmetic Mean Level	L_m
Traffic Noise Index	TNI
Cumulative Noise Level exceeded	
during 1% of time (peak level)	L_1
during 5% of time	L_5
during 10% of time	L_{10}
during 50% of time (mean level)	L_{50}
during 90% of time	L_{90}
during 99% of time (background level)	L_{99}

The investigation was carried out in a suitable lecture room with the same acoustic properties at all places. 93 subjects forming a random sample of 800 residents living at much frequented streets and with experience of daily traffic noise were exposed during 3 consecutive days to the 9 recorded noises in their natural intensity. Fig. 2 shows the lecture room during the experiments. The recorded noise situations were replayed in different successions on each of the days.

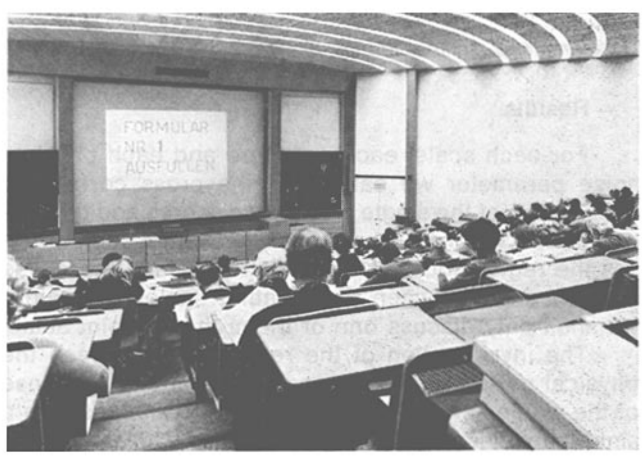

Figure 2
The lecture room during the experiments

[1] This investigation was supported by the Hoffmann La Roche Foundation for interdiciplinary studies and by the Swiss Research Foundation.

They had a duration of 12 minutes each and were presented with breaks of 4 respectively 16 minutes in between. During the first 9 minutes of each exposure the subjects read or did some leisure work. After a light signal they filled out the noise annoyance rating scales during the last 3 minutes.

Each day the subject received a booklet containing all the scales of the day in succession. At each exposure they filled out the 3 noise rating scales shown in Fig. 3:

- a 5 point scale with 4 progressively labelled scores and open ends,
- a 22 point scale with 8 progressively labelled scores and 3 unlabelled scores between these. To avoid a copyeffect by the subjects filling out the 3 scales in succession, this scale was inverted, and
- a noise thermometer with 10 graduated scores according to the centigrade thermometer. The ends of this scale were labelled «unbearable» and «of no importance» respectively.

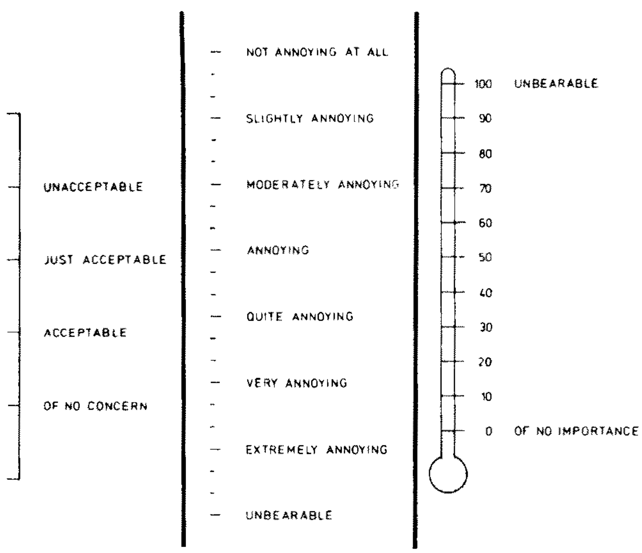

Figure 3
The three noise rating scales

Results

For each scale, each exposure and each physical noise parameter we calculated the cross correlation coefficients of the single annoyance scores and the percentual deviations of the mean annoyance scores versus the regression line. As a matter of fact, there was no difference between the 3 rating scales. Therefore we shall only discuss one of them, the 22 point scale.

The investigation of the relationship between the physical noise parameters and the subjective response of the whole sample generally gave correlations with a significance less than 1 permill. *Table 2* shows the cross correlation coefficients of the single annoyance scores versus 9 physical noise parameters. Of greater

		r_{single} N=2505	DEVIATION % MEAN	MAX
EQUIVALENT NOISE LEVEL	L_{eq}	0,73**	6,3	16,6
NOISE POLLUTION LEVEL	L_{NP}	0,58**	14,0	33,1
ARITHMETIC MEAN LEVEL	L_m	0,71**	7,2	28,2
TRAFFIC NOISE INDEX	TNI	0,41**	18,3	37,5
CUMULATIVE NOISE	L_1	0,68**	10,7	24,7
LEVELS	L_5	0,72**	8,6	22,3
	L_{10}	0,73**	7,6	20,0
	L_{50}	0,68**	8,6	35,3
	L_{99}	0,61	15,4	28,0

** $p < 0{,}001$

Table 2
Correlation coefficients and deviations of the annoyance scores

interest are the percentual deviations of the mean annoyance scores versus the regression line. The highest correlation coefficients as well as the smallest percentual deviations were found for the equivalent noise level and the cumulative frequence noise level exceeded during 10 % of time.

Figure 4 shows the regression line of the equivalent noise level and the mean annoyance scores of each of the 9 noise situations.

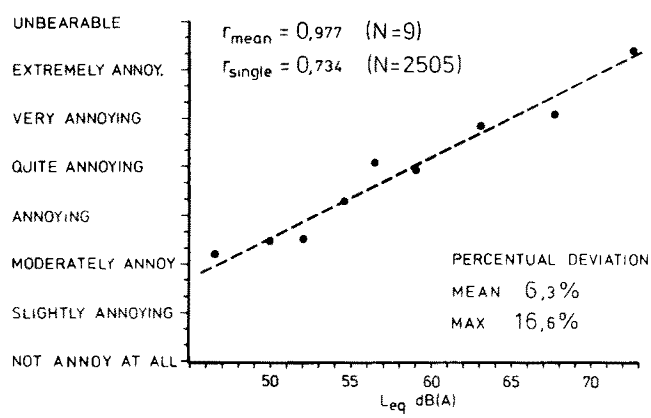

Figure 4
Cross mean values of annoyance versus L_{eq}
Single N = 93 subjects x 3 days x 9 exposures.

The analysis of the results as well as the consideration of well-known facts led to the hypothesis that the subjective annoyance caused by traffic noise may be mainly dependent on the following 3 acoustic parameters:

- the peak noise level, well characterised by the cumulative frequency noise level exceeded during 1 % of time [L_1],
- the mean noise level, well characterised by the cumulative frequency noise level exceeded during 50 % of time [L_{50}],

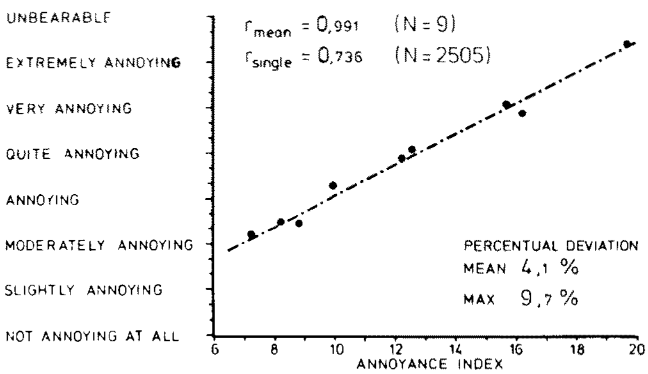

Figure 5
Annoyance versus a new noise index
Annoyance index = 0,29 x L_1 + 0,27 x L_{99} – 19.

– and the background noise level, well characterised by the cumulative noise level exceeded during 99 % of time [L_{99}].

We tried a least square best fit analysis of the mean annoyance scores to find an optimal regression formula. The results are shown in figure 5. The smallest mean percentual deviation as well as the maximal fit was found with the formula: 0,29 x L_1 + 0,27 x L_{99} – 19

As shown by Fig. 5 the obtained correlation coefficient is not significantly higher than by the equivalent noise level but the deviations of the annoyance scores versus the regression line are more balanced.

Conclusions

We came to the conclusion that those classical acoustic parameters which are related to the mean level with some respect to the peaks are the most adequate to annoyance caused by traffic noise. The equivalent noise level or the cumulative frequency noise level exceeded during 10 % of time are the most appropriate classical parameters to estimate traffic noise.

Summary

Nine different traffic situations were recorded on tapes and acoustically analyzed. Subsequently 93 subjects were exposed to each recorded traffic noise situation, and the subjects had to rate their feeling of annoyance.

The highest correlations were obtained between annoyance and the following parameters:

- equivalent noise level L_{eq}:r_{ind} = 0,73
- cumulative frequency noise level L_{10}:r_{ind} = 0,73
- arithmetical mean value L_m:r_{ind} = 0,71.

A regression analysis with the decisive acoustic values led to a formula which did not result in a marked improvement of the above mentioned correlations.

Zusammenfassung

Strassenlärm und Störwirkung

Neun verschiedene Verkehrslärmsituationen wurden auf Magnettonbänder aufgenommen und nach akustischen Gesichtspunkten analysiert. Anschliessend wurde der Verkehrslärm in einem Auditorium 93 Versuchspersonen vorgespielt und das Ausmass der Belästigung mit Selbsteinstufungsverfahren gemessen.

Die höchsten Korrelationen zur Belästigung wurden mit folgenden Lärmmassen erhalten:

- äquivalenter Dauerschallpegel L_{eq}:r_{ind} = 0,73.
- Summenhäufigkeitspegel L_{10}:r_{ind} = 0,73.
- arithmetischer Mittelwert L_m:r_{ind} = 0,71.

Eine Regressionsanalyse mit den entscheidenden akustischen Massen führte zu einer Formel, die keine erhebliche Verbesserung der oben erwähnten Korrelationen ergab.

Résumé

La gêne due au bruit du trafic routier: mesures en laboratoire

Neuf différentes situations de bruit du trafic routier furent enregistrées sur bande magnétique et analysées du point de vue acoustique. Par la suite, 93 sujets furent exposés à ce bruit dans un auditoire et priés d'exprimer leur gêne par un procédé d'auto-évaluation.

Les corrélations les plus marquées furent obtenues entre la gêne et les paramètres suivants:

- Niveau sonore équivalent permanent L_{eq}:r_{ind} = 0,73.
- Somme de fréquences L_{10}:r_{ind} = 0,73.
- Moyenne arithmétique L_m:r_{ind} = 0,71.

Une analyse de régression avec les paramètres acoustiques décisifs aboutit à une formule qui ne prévalait pas sur les corrélations mentionnées plus haut.

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