The Effects of Determination of Acoustic Data in Field Studies

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Summary: When calculating the difference in the annoyance between rail traffic noise and road traffic noise, the method of determining the noise exposure can influence considerably the degrees of difference in the annoyance. Consequently, in the case of disturbed sleep, that were examined by questionnaire, the degree of disturbance can vary between 11 and 20 dB(A).

1. INTRODUCTION

In order to estimate difference in the annoyance road traffic noise and rail traffic noise, the distance between the straight lines that arise from the relation between the two sources of noise annoyance is calculated (compare among others [1]). Figure 1 illustrates the principle of the calculation of differing levels of noise exposure.

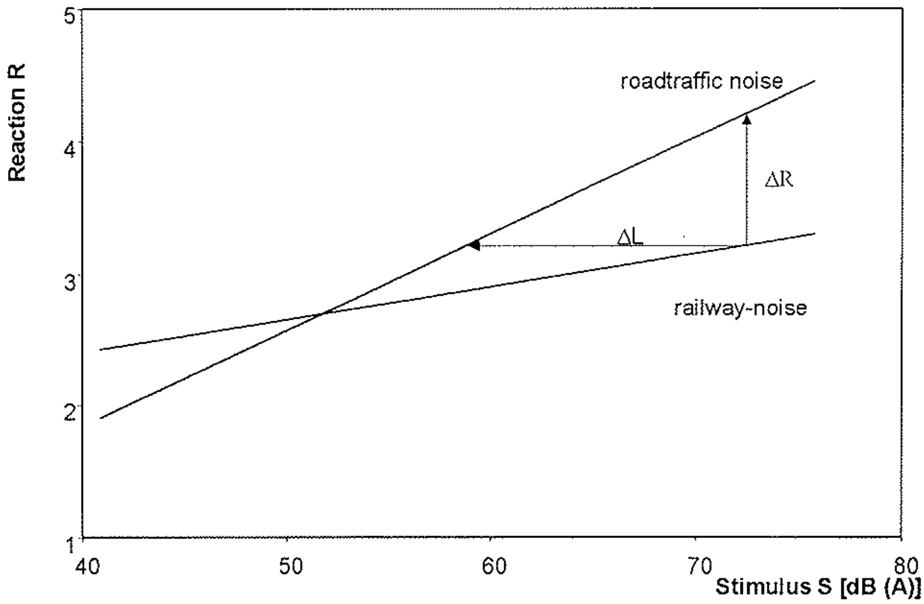

FIGURE 1: Estimation of the difference in the annoyance between two noise sources

The position of the straight lines results from the determined reaction levels and the acoustic data. The reaction levels represent the reaction expressed by the respondents when filling in questionnaires; they chose their answers from a scale of 5 alternatives. Thus the degree of disturbance felt by an individual subject can be relatively clearly defined.
Compared to other acoustic parameters, the average sound pressure level L_{Aeq} has emerged as the best parameter to describe the noise exposure of disturbance and annoyance from traffic noise. The determination of the average sound pressure level, decisive for the comparison, can be done by measuring, calculating, or by a combination of the two methods. In order to measure and calculate sound, varying methods can be used, depending on the source of sound. The calculation of

the varying levels of perceived noisiness between traffic on railways and roads on the basis of analysis of sleep disturbance [2] serves as an example with which to illustrate how significant the method of determining noise exposure is for the difference in the annoyance between the two traffic noise sources.

2. DETERMINATION OF NOISE EXPOSURE

2.1 Estimation of acoustic emission

Acoustic emission can either be measured or calculated. It is measured according to EDIN 45642 „Messung von Verkehrsgeräuschen“ [3] according to which a pre-determined number of vehicles pass the measuring instruments at a pre-determined distance from each other while the noise level is being measured. Simultaneously, the relevant parameters such as speed, traffic structure and concentration etc. are assessed. The sound emission in the reference distance of 25 meters can be calculated from the data collected, and this is thus the emission at the point in time when the sound was measured.

Calculation of sound emission is carried out in Germany according to RLS-90 [4] for road traffic, and according to Schall03 [5] for railway traffic. Both guidelines were introduced with the 16.BImSchV [6] as an obligatory rule for computing as regards new construction and extension of roads and railways. According to these guidelines, the sound emission can be determined on the basis of data regarding the volume and composition of traffic that was collected on the spot, or it can be determined on the basis of data from the relevant authorities. The latter must be applied in the construction and extension of traffic routes in accordance with the regulations of the 16. BImSchV.

The following chart illustrates the differences in the sound emission in the areas analysed for the research into sleep patterns.

Area	Measured emission	Calculated on the basis of measured data	Calculated on the basis of data from authorities
	Noise emission at night, $L_{m,e}$ [dB(A)]		
Areas with predominant road traffic			
Bottrop	54.5	54.8	55.9
Langenfeld	54.7	54.5	59.9
Kreuztal	58.6	58.8	61.2
Hilchenb.	57.0	56.6	60.6
Seelbach	57.5	56.0	59.4
Burg	58.8	56.4	59.4
Areas with predominant railway - traffic			
Bönen	71.8	69.9	73.7
Essen	71.4	70.0	74.3
Oelde	72.7	72.2	77.0
Rheda	71.4	72.2	77.0

TABLE 1: Noise emission in the areas of the sleep study [1]

It can be seen that when the results from measuring are compared with the figures from calculations on the basis of measurements in road and in railway traffic, the data from measuring is usually the lower figure, which is probably due to the fact that the quality of the road surface is sometimes over-estimated. A great difference between road and railway emerges when the emissions from the actual situation are compared with the situation based on data from the authorities (e.g. DB AG, road construction offices). In this case the levels for sound emissions from official data are above the actual sound emissions by between 0,6 and 3,6 dB(A) on the road and between approx. 1,9 to 5,6 dB(A) on the railways.

2.2 *Estimation of noise exposure*

Regardless of the method chosen to determine the noise exposure, the choice of the representative immission point is of vital significance. In field studies often the façade, facing the source that is being examined, is analysed; when examining, for instance, sleeping disorders, measurements and calculations carried out outside the bedroom can, however, also be very relevant. The difference between facing a façade or not can amount to 20 dB(A). In order to simplify matters, measurements and calculations outside the bedroom are considered in this context.

In field studies it is virtually impossible to determine sound exposure purely on the basis of acoustic measurements because the large number of participants necessary for any field study results in the need for so much equipment and a consequent complex evaluation of the results, (in the study in question a total of 1600 respondents were interviewed, and the body movement was measured with actimeters approximately 400 subjects while they were asleep). Therefore measurements and calculations were used in conjunction in order to give the most precise picture of noise pollution (see [2,7]).

There are a number of different ways of calculating acoustic immission; as an example for demonstration the differences between rail and road traffic noise, the methods for assessment according to 16.BimSchV [6] will be used. In this regulation, the RLS90 [4] for road traffic noise and the Schall03[5] for rail traffic noise is to be used. On this basis calculations with respect of ground absorption, meteorology absorption, shielding caused by buildings, reflection etc. can be done with one particular aspect of the Schall03 for railway noise: the shielding caused by buildings is omitted due to individual buildings behind the first row of houses. Depending on the given conditions at a certain location, application of the above methods can produce extremely varying results. Especially in large distances in a great density of development the noise exposure with the same emission is rather lower, when calculating road traffic noise in comparison to rail traffic noise. Therefore two calculation methods will be considered: one with a consequent application of the regulations and the other one with the same propagation model for both noise sources. To sum up, the following methods of determining the average sound pressure level will be examined:

		Method	**Comment**
E1	Emission	Measurement	measures on EDIN 45642
E2	Emission	Calculation	basis data of measures
E3	Emission	Calculation	basis data authorities
I1	Noise exposure	Measurement / calculation	basis time of measurements
I2	Noise exposure	Calculation	road with RLS90 / rail with Schall 03 with shielding of buildings
I3	Noise exposure	Calculation	road / rail consequently on 16.BImSchV

TABLE 2: Selected methods of calculation and measurement

3. DIFFERENCES IN THE NOISE ANNOYANCE IN DEPENDENCE OF THE METHOD USED TO MEASURE NOISE EXPOSURE

The effect that the above-described methods of determining noise exposure have on the different levels of noise annoyance from either railway or road traffic are illustrated by the sleep disorders of respondents. To do this, sound level scenarios are created to determine acoustic emission and acoustic immission. In order to assess the degree of annoyance perceived, the question „To what extent do you feel disturbed at night by noise from road traffic (noise from railway traffic)?“ with the choice of answers, „not at all, a little, moderately, rather, very“ was taken as an example of reactions. The following chart shows a comparison of the different degrees of disturbance calculated for these reaction variables.

Scenario	Emission	Noise exposure	Difference in the sleep disturbance $L_{eq, night}$ = 50 dB(A)
1	E1	I1	**11.4**
2	E2	I2	**12.3**
3	E3	I2	**15.8**
4	E2	I3	**14.4**
5	E3	I3	**19.5**

It can be seen that, depending on the acoustic scenario being considered, the different degrees of disturbance felt between the noise from railway or road traffic swings from 11.4 and 19.4 dB(A). The values in the above table mean that for „sleep disturbance“ as the reaction variable in questionnaire, noise from railway traffic is not perceived as being so disturbing as noise form road traffic.

4. DISCUSSION

The differences in the levels of noise exposure, that were determined with the help of selected acoustic scenarios, vary considerably. The differences of noise annoyance, that were estimated on the basis of data that represents a realistic acoustic situation at the time of questioning, are, relatively speaking, the lowest; whereas the corresponding figures, as legally stipulated according to the 16.BImSchV, are, relatively speaking, the highest. This means that when determining the difference in the annoyance between road and railway traffic noise for legal actions ("railway-bonus"), the compulsory methods of calculation must be taken into consideration together with the methods applied in the underlying studies. It also becomes apparent that a comparison of the results of surveys into noise annoyance must consider and examine possible differences in determining perceived noise, as well as the determination of noise exposure beyond the acoustic parameters used.

REFERENCES

(1) B. Rohrmann: Psychologische Forschung und umweltpolitische Entscheidungen: das Beispiel Lärm, Wetsdeutscher Verlag, 1984

(2) B. Griefahn, U. Moehler, R. Schuemer.(Hrsg) Interdiziplinäre Feldstudie zum Unterschied zwischen Schienen - und Straßenverkehrslärm, München 1999

(3) Entwurf DIN 45642 "Messung von Verkehrsgeräuschen", 1997

(4) Richtlinie für den Lärmschutz an Straßen (RLS-90) Ausgabe 1990

(5) Richtlinie zur Berechnung der Schallimmissionen von Schienenwegen, Schall03, 1990

(6) 16. Bundesimmissionsschutzverordnung (16.BimSchV-Verkehrslärmschutzverordnung) 1990

(7) M. Liepert, U. Moehler, R. Schuemer, B. Griefahn,: An interdisciplinary study on railway and road traffic noise: acoustical results *Proceedings of Forum Acusticum*, Berlin 1999