An Interdisciplinary Study on Railway and Road Traffic Noise: Acoustical Results

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Summary: In a field study, carried out between 1994 and 1998, the noise impact as well as psychological reactions by questionnaire were measured for 1600 persons in 4 areas exposed either to railway or to road traffic noise. Furthermore body movements during sleep were assessed for 377 persons by actimeters. The noise impact was obtained by noise calculations and, for the sample of the 377 sleep subjects, by measurements inside and outside the bedrooms. The acoustical analyses show typical differences between road and rail traffic noise.

1. INTRODUCTION

In many countries, the regulations for the evaluation of traffic noise pollution give limit values that are around 5 dB(A) lower for railway traffic than for road traffic („railway - bonus"). This difference between the two means of transport is the result of the difference in the nuisance caused by rail and road traffic noise with the same noise level L_{Aeq}.
Reviews of the literature carried out by Schuemer & Schuemer-Kohrs, 1991 (1), Moehler & Schuemer-Kohrs, 1985 (2), and Moehler, 1989 (3), summarise the results of a number of international studies on the railway bonus.
In all these studies, the sleep disturbances were evaluated in particular through traffic noise at night determined by questionnaires by day. Since on the one hand particularly at night the railway bonus is rather high and on the other hand there is a lack of factual certainty as to whether the disturbances about which respondents are questioned by day correctly reflect the actual disturbances at night, it proved necessary to study the night-time disturbance in particular in more detail through specific surveys. For this reason a sleep study was carried out by an interdisciplinary team.

2. METHODS

The study plan was that acoustic measurements, social survey interviews and physiological measurement of sleep disturbance would be carried out in areas with predominant railway noise or road traffic noise. The aim of the social survey was to determine both day-time disturbances and night-time disturbances and thus to obtain up-to-date results on the difference in the problems caused by road and rail. The physiological part of the study, on the other hand, covered the noise-related disturbance of sleep and testing the source difference.
The acoustic stress caused by the relevant type of noise was to be varied on the one hand by use of areas with different traffic densities and on the other hand by selection of respondents

at different distances from the noise source. For the study plan, 4 different area types were defined which were each to be formed from 2 study areas. The area types were characterized by the type of the dominating noise source and by high or low traffic density.
In this study 1600 subjects were interviewed in the social survey. Furthermore 377 of these subjects took part in the physiological part of the study concerning sleep disturbances. The acoustic impact was determined by calculation of the individual outdoor noise level. For the participants in the physiological sleep survey, accompanying acoustic measurements were to be carried out outside and inside the bedroom.
The data in the study were collected in the following steps:

- Social survey interviews with subsequent acquisition of subjects for physiological study
- Acoustic and physiological measurements over 2 x 5 survey nights per area
- Second part of the social survey interviews with smaller random sample
- Calculation of the acoustic data for interview respondents

Acoustical survey: The acoustical survey for the whole sample was carried out by calculation of individual average noise levels. The values were calculated separately for each of the two sources and the relevant periods of day and night. The calculations were made on the basis of the standards regarded in Germany as being state of the art.
For respondents who also participated in the physiological sleep study, extensive sound level measurements were carried out during the study period of 2 x 5 nights, which were then used to prepare individual noise-time patterns for these nights (4). The aim of these patterns was, on the one hand, to allow an event-related evaluation of the sleep disturbances recorded in the same time period and on the other hand to allow a great number of acoustic indices to be calculated. Since measurements could not be carried out on all respondents in an area at the same time during the entire sleep survey, continuous measurements at the emission source predominating in the area were supplemented by short-time measurements on respondents (approx. 1 h). The short-time measurements were made both outside and inside the bedroom of the participating respondents. From the combination of permanent measurements with the short-time measurements, individual source specific noise-time patterns were calculated, using a specially developed algorithm, for the study period for all the respondents in the sleep survey.

Social survey: The surveys for the social part of the study were carried out in face to face interviews using more or less standardised questionnaires (for more details see (5)). Because of the wide scope of the themes in the interviews, the questions were divided between two interviews or questionnaires per respondent.

Physiological study: To determine sleep disturbances caused by rail or road traffic noise physiological measurements were taken over 2x5 survey nights per area. Among other indicators for sleep disturbance mainly the body movement recorded by actimeters.

3. RESULTS

The observed sound levels in front of the housings of the subjects at day lay between 42 an 78 dB(A) in road areas and between 45 and 68 dB(A) in rail areas. The values for the night are between 40 and 68 dB(A) in road areas and between 50 and 70 dB(A) in rail areas.

The number of passing vehicles in the road areas lay between 12.000 and 20.000 vehicles per day. In the rail areas between 190 and 260 trains were passing by per day.

Some of the results of the acoustical measurements and calculations are given in the following:

- The noise-time pattern of road traffic noise differs significantly from that of rail traffic noise. Whereas noise levels of road traffic decrease about 10 dB(A) at night, the noise levels of rail traffic remains more or less constant over 24 h (see fig. 1).

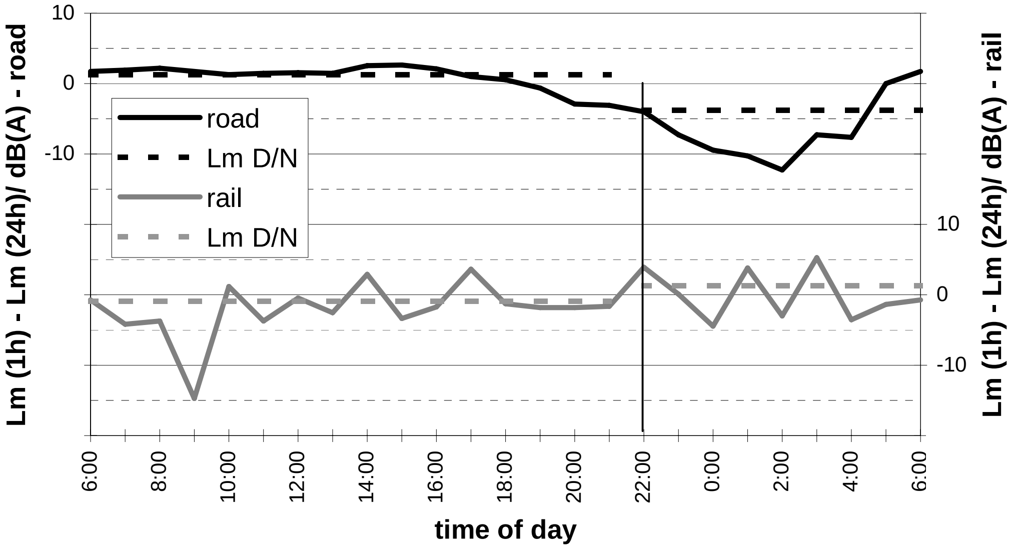

FIGURE 1: Time varying pattern of the hourly average noise level in a rail and a road area

- Subjects in rail areas live in greater distance from the sound source than subjects in road areas with comparable noise levels over 24 hours. This is due to the higher emission levels of railway lines than of road traffic.
- The rise time of the noise of passing cars and passing trains does not differ in the observed distances from the noise source and the observed speeds of cars and trains.
- The frequency spectrum of road traffic noise contains more low spectral components than that of rail traffic noise.
- Subjects in road areas tend to close their windows at night more often than subjects in rail areas. This is true for the whole observed noise level range.
- Different noise level measures (e.g. L1, L1-L95, L_{dn}, L_{etm} etc.) show only in few cases better correlations with annoyance reactions determined by questionnaire than the A-weighted average noise level
- Noise levels differ differently between calculated and measured data for road and rail traffic noise. Therefor noise level scenarios with different input data for the calculations (such as number of passing vehicles, speed, number of goods trains etc.) were defined (for more details see (7)).
- Measured average indoor noise levels in the bedrooms at night were found to be up to 20 dB(A) or more higher than source specific determined (measured emission levels reduced by the abatement by propagation and shielding) indoor noise levels (see fig.2). Thus in most of the cases other sound sources (radio, TV-sets, snoring etc.) were dominating indoor noise levels.

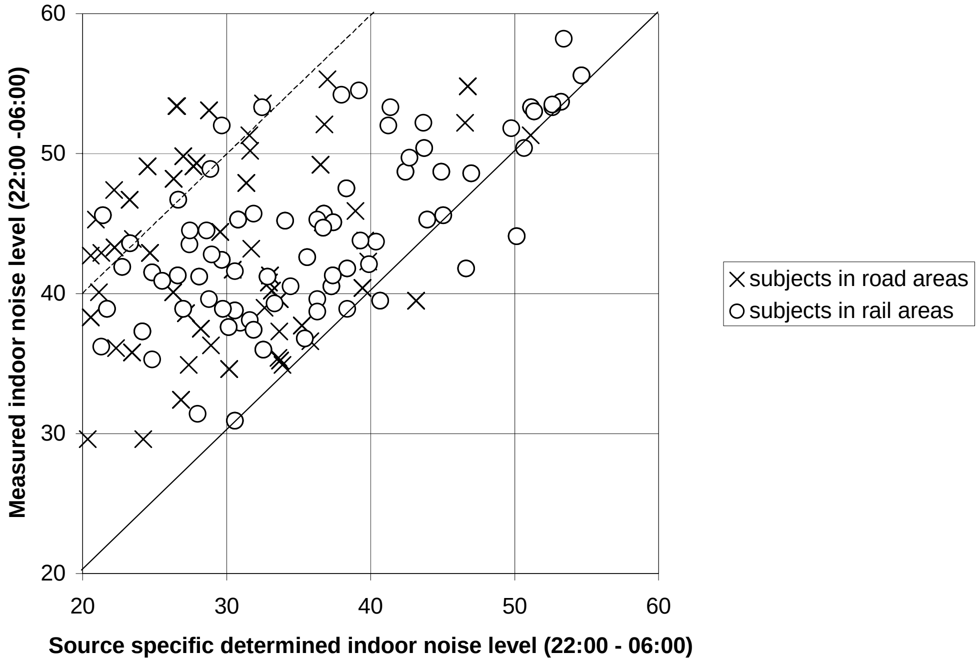

FIGURE 2: Source specific versus non source specific indoor noise levels

CONCLUSIONS

The acoustical exploration show typical differences between road and rail traffic noise. The measurements of annoyance and sleep disturbance were conducted in areas for typical situations near roads and railway lines with relatively high traffic density in Germany. High speed traffic (e.g. ICE) or railway lines exclusively for goods trains were not examined. These subjects are examined in other currently conducted studies.

REFERENCES

(1) R. Schuemer, A. Schuemer-Kohrs: The nuisance of rail traffic noise in comparison with other sources of noise, comments on research results; *Zeitschrift für Lärmbekämpfung* (Magazine for Combating Noise), 38 (1991), 1-9

(2) U. Moehler, A. Schuemer-Kohrs: Literature survey concerning the effect of railway noise alone and railway noise compared with the noise from other traffic sources, ORE, DT 170 (C163), 1985

(3) U. Moehler: Community response to railway noise: a review of social surveys; Journal of Sound and Vibration 120, 321-332, 1988

(4) M. Liepert et al.: Acoustical measurement in an interdisciplinary field study of sleep disturbance by rail and road traffic noise; *Fortschritte der Akustik* (Progress in Acoustics), DAGA, 409-410, 1997

(5) D. Schreckenberg, A. Schuemer-Kohrs, R. Schuemer, B. Griefahn, U. Moehler: An interdisciplinary study on railway and road traffic noise: Annoyance differences. *Proceedings of Forum Acusticum*, Berlin 1999

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

(7) U. Moehler, M. Liepert, R. Schuemer, B. Griefahn,: Methods of Determination of acoustical data in field studies. *Proceedings of Forum Acusticum*, Berlin 1999