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An Interdisciplinary Study on Railway and Road Traffic Noise: Annoyance Differences

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Summary: For equal noise levels, railway noise is all in all less annoying than road traffic noise. But with regard to some specific aspects railway noise is more disturbing than road traffic noise.

1. INTRODUCTION

Several field studies conducted in Europe have shown that, for equal noise levels (Lm), railway noise is less annoying and disturbing than road noise (the so-called ‘railway bonus'; see e.g. the summarizing articles [7, 10]). A study conducted in Germany about 20 years ago [9] showed that the size of this difference in annoyance depends, among other factors, on: a) the annoyance / disturbance response considered, and b) time of day (daytime / night). Although the size of the difference depends on the factors mentioned, a *general* ‘bonus' of 5 dB(A) has been set by the German noise regulations, i.e. it is assumed that railway traffic noise must be 5 dB(A) louder than road traffic noise to achieve the same amount of annoyance. There has been some debate on the justification for this bonus regulation. Thus, it was decided to conduct a new study on the annoyance difference between road and railway traffic noise.

2. METHOD

Acoustical measurements have been taken in 8 areas with either predominant railway or road traffic noise. Noise levels are estimated for each source and for each individual subject [8]. Residents in these areas were interviewed with regard to their annoyance and disturbance by each of the two sources. 1600 interviews were done altogether in the 8 areas. Although both sources were present in each of the areas and although subjects (*Ss*) were asked to report their annoyance with regard to each of the two sources, only the responses to the dominant source by each *Ss* were taken into account in the analyses. (A source was considered as ‘dominant' for a *Ss* a) if he/she lives in an area where this source is on the whole predominant, and b) if the individual noise level for this source is at least 40 dB(A) during the day *and* at night, and c) if it is 5 dB(A) or more higher than the noise level for the other source.)

The data allow one to test whether there is a difference in annoyance between the two sources. The analyses are based on the ‘general linear model’ (GLM). A two-factorial design is used, with ‘source’ (railway / road) and ‘noise level’ (A-weighted sound level Lm, expressed in decibels; 4 classes of 5 dB(A) each with midpoints at 52.5, 57.5, 62.5 and 67.5 dB(A)) as the independent variables. Separate analyses were done for each time of day: a) daytime, b) at night, and c) for 24h (day *and* night). Several aspects of annoyance / disturbance were used as dependent variables in these analyses. From these variables only the following (representative of the whole set of variables) are considered here: (a) for *daytime:* ‘COM: disturbance of communication - indoor’, composite score, ‘REL: disturbance of relaxation - outdoor’, and ‘TDD: total disturbance - daytime’; (b) for the *night:* ‘TDN: ‘total disturbance - at night’; and (c) for the *whole day (24h; day and night)*: ‘GA: general annoyance'. - All variables are measured on a 5-point verbal scale (1: not / 5: very annoyed / disturbed). Results for further annoyance variables are not presented here because of lack of space. The design allows univariate as well as multivariate tests for the main effects and their interaction. Only the results of the univariate analyses for the variables mentioned are reported here (see [3] for more details). A significance level of alpha=0.01 was used for all tests.

3. RESULTS

The interaction effect ‘source x noise level’ was not significant in any of the analyses; i.e. the mean difference between the two sources (railway / road traffic) is about the same for all noise levels. The main effect of ‘noise level’ was significant in all analyses: the higher the noise level, the higher the annoyance / disturbance. - The main effect of ‘source’ differs for each of the dependent variables considered here. The results with regard to the factor ‘source’ are described separately for the annoyance / disturbances: a) during the day (6am – 10pm), b) at night (10pm - 6am), and c) for the general annoyance (day and night, 24h):

Annoyance / disturbances during the day: the univariate analyses with regard to the factor ‘source’ show that the annoyance differences between the sources (road / railway noise) vary depending on the annoyance / disturbance aspect considered: there is a significantly greater disturbance for railway than for road traffic noise for the variable referring to ‘communication indoor’ (COM: $F=71.5$; $p=0.01$; the mean responses for railway and road are summarized in table 1). In contrast to that, a significantly greater disturbance due to road than to railway traffic is found for the ‘total disturbance - during the day’ (TDD: $F=8.5$; $p<0.01$). For ‘relaxation - outdoor‘ (REL) there is a tendency for greater disturbance for road than for railway traffic noise, but the ‘source effect’ is not significant ($F=5.6$; $p<0.02$).

A higher intensity of disturbance due to road traffic noise is found for some further variables not described here in detail; for example, there is a stronger tendency to close the windows during the day for road than for railway noise.

Annoyance / disturbances at night: the analysis with regard to the factor ‘source’ shows that the ‘total annoyance at night’ (TDN) due to road traffic noise is significantly higher than the disturbance attributed to railway noise ($F=46.0$; $p<0.01$).

TABLE 1: Response means (M) and standard deviations (Std) for each source

		ROAD				RAILWAY			
daytime		N	M	Std	M*	N	M	Std	M*
COM	disturbances of communication – indoors	502	2,05	1,17	**1,90**	558	2,33	1,30	**2,60**
REL	relaxation - outdoors	492	3,14	1,52	**3,04**	543	2,57	1,48	**2,79**
TDD	total disturbance – daytime	492	2,83	1,22	**2,70**	543	2,27	1,20	**2,45**
night									
TDN	total disturbance – at night	543	2,41	1,21	**2,51**	583	2,15	1,30	**2,13**
24h									
GA	general annoyance – day *and* night (24h)	552	3,34	1,24	**3,22**	592	2,83	1,27	**2,90**
M*: Means adjusted for the other effects in the model.									

Similar results are obtained for 'sleep disturbances': *Ss* report suffering from sleep disturbances caused by road traffic noise to a higher degree than from disturbances caused by railway noise. Furthermore, as during the day, there is also a stronger tendency at night to close the windows for road than for railway noise.

Annoyance for day and *night (24h):* the univariate test for the factor 'source' indicates that the 'total general annoyance' (GA) is significantly higher for road than for railway noise (F=17.6; p<0.01). Correspondingly, the proportion of 'highly annoyed' *Ss* (i.e. those choosing 4 or 5 on the 5-point 'general annoyance' scale) is higher for road than for railway within each class of noise level. - Similar results are found for some further variables not described here in detail; for example, *Ss* report that they are startled, made nervous or suffer from headaches to a higher degree because of road than because of railway noise. Furthermore, a higher proportion of *Ss* choose road traffic noise when asked to compare directly the annoyance caused by road and by railway noise and to name the source which is more annoying.

Annoyance differences expressed in units of Lm (ΔL-values): the correlations between the annoyance / disturbance responses and the noise level (Lm) are rather low ($0.2 \le r \le 0.4$) if individual responses are correlated with Lm. The correlations are distinctly higher ($r \approx 0.9$) if mean responses within classes of Lm (class width: 2,5 dB(A)) are correlated with the midpoints of the Lm-classes. To describe the relationship between the annoyance / disturbance responses and the noise level (Lm) a linear function can be estimated for each source (road / railway trafic) by means of regression or an estimation method described by Madansky [5]. Based on the linear functions describing the relationship between the mean annoyance / disturbance responses and the noise level classes it is also possible to estimate the annoyance difference between the two sources expressed in units of the noise level (ΔL in dB(A). The ΔL-estimation method is described in [9]). The ΔL comprises the size of difference (in dB(A)) by which railway noise must be louder than road traffic noise to reach the same amount of annoyance. Such estimates of ΔL can be conducted for different noise levels. Averaging the ΔL-values for the lower and upper noise levels (at 50 or 70 dB(A)) results in the following mean ΔL-values: for the 'total disturbance - daytime' (TDD) + 3.4 dB(A), for 'disturbance of comunication - indoors' (COM) – 8.0 dB(A), for the 'total disturbance at night' (TDN) + 8.0 dB(A), and for the 'general annoyance – day *and* night' (GA) + 4.0.

4. DISCUSSION

The results of this study confirm on the whole the results from previous field studies (e.g. [2, 4, 6, 9]; for some conflicting results see [11]) and laboratory studies (e.g. [1]). For example, Moehler et al [9] also reported greater annoyance due to railway noise (railway disadvantage) for variables referring to communication and greater annoyance due to road traffic noise (rail way 'bonus') for variables like 'general annoyance' and 'total annoyance at night'. - Finally, in assessing the results one has to take into account that only those residents were interviewed who live along a railway line where the number of trains passing is less than 260 in 24h, where the speed of passing trains ist restricted to an upper limit of 200 km/h, and where the proportion of freight traffic does not exceed 67% (of the total number of trains passing in 24h). Thus, two further studies (currently being conducted) deal with the annoyance caused by high speed trains (the ICE) or by freight traffic (Zeichart et al, in prep.). - It is *not* our duty and it was *not* an objective of this paper to support or to question the German railway-bonus regulation; such an regulation has take into account several other factors rather than the results of a single study. But the results of this and of other studies (currently being conducted) may contribute to the *total* evidence such an regulation is based on.

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