ANNOYANCE DUE TO RAILWAY AND ROAD TRAFFIC NOISE: FIRST RESULTS OF AN INTERDISCIPLINARY STUDY

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1. INTRODUCTION

Several field studies have shown that for equal immission levels (Lm), railway noise is less annoying and disturbing than road noise (the so-called 'railway bonus'; see e.g. the summarizing articles [1, 2]). A study conducted in Germany about 20 years ago [3] showed that the amount of this difference in annoyance depends on: a) the annoyance / disturbance response considererd; b) time of day (daytime / night); c) the noise level (among other factors). In spite of the dependency of the amount of the difference on the factors mentioned, a *general* 'bonus' of 5 dB(A) has been set by the German noise regulations (the 'Bundesimmissionsschutzgesetz'), i.e., it is assumed that railway traffic noise may be 5 dB(A) louder than road traffic noise to reach the same amount of annoyance. There has been some debate on the justification of this bonus regulation. Some critics argued, for example, that the bonus is not valid any longer because the road and railway traffic has changed in the last years. Thus, it was decided to conduct a new study on the annoyance difference between road and railway traffic noise. This study has not yet been completed. Thus, only first preliminary results may be described here.

2. METHOD

Acoustical measurements have been taken in 8 areas with either predominant railway or road traffic noise. Both sources were present in each of the areas. 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.

The data allow to test whether there is a difference in annoyance between the two sources. The analyses are based on the 'general linear model' (GLM). A one-factorial design is used: with 'source' (railway / road) as the independent variabale and the immission noise level as a covariate. (The noise levels are estimated for each source and for each individual subject by taking into account the distance between the home of the subject and the source and the number of trains or cars passing.) Seperate analyses were done for each time of day: a) daytime, b) at night, and c) for 24h (day *and* night). The dependent variables considered in the analyses are: (a) for *daytime:* 'DD1: disturbance of conversation - indoor', 'DD2: disturbance of listening to radio/music and TV', 'DD4: disturbance of relaxation - indoor', 'DD6: disturbance of conversation - outdoor', 'DD7: disturbance of relaxation - outdoor', and 'DDT: total disturbance - daytime'; (b) for the *night:* 'DN8: preventing from falling asleep', 'DN9: wakening up at night', 'DN10: wakening up in the morning', and 'DNT: 'total disturbance - at night'; and (c) for the *whole day (24h)*: 'GA: general annoyance' and 'TD: total annoyanace / disturbance at home'. - All variabales but one are measured on a 5-point verbal scale (1: not / 5: very annoyed / disturbed). Only the 'total disturbance - at night' (TD) is measured on 11-point graphical scale (from '0: not at all annoyed' to '10: extremely annoyed'). - The design allows univariate as well as multivariate tests for the main effect. (Preceding two-way analyses with 'source' and 'noise level classes' as independent factors showed that the interaction between the two factors is rather weak.)

3. RESULTS

The results are described seperately for the annoyance / disturbances a) during the day (6am – 10pm), b) at night (10pm - 6am), and c) for annoyance responses not specifying the time of day.

a) Annoyance / disturbances during the day: The multivariate test shows that the factor 'Source' is significant (source: F=49.4; p<=.0001; the F- and p-value for the multivariate test refer to the 'partial sums of squares' and the F-approximation for Wilk's lambda).

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 significant greater disturbance for railway than for road traffic noise for 2 variables referring to communication indoor (see Table 1): DD1: conversation - indoor (F=50.6; p<=.0001); DD2: listening to music / radio / TV (F=78.0; p<=.0001). In contrast to that, a significant greater disturbance due to road than to railway traffic is found for another 2 variables: DDT: total disturbance - during the day (F=25.1; p=.0001) and DD7: relaxation - outdoor (F=11.4; p=.0008). For the remaining 2 variables (DD4, DD6) the 'source effect' is not significant (F<1.0).

A higher intensity of disturbance due to rood 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.

Table 1. Response means and standard deviations (std) for each source (road / railway noise): daytime

Source	N	DD1: conversation - indoor		DD2: listening to music, radio, TV		DD4: relaxation - indoor		DD6: conversation - outdoor		DD7: relaxation - outdoor		DDT: total disturbance - daytime		Lm, day
		Mean	std	Mean	std	Mean	std	Mean	std	Mean	std	Mean	std	Mean
RAIL	703	2.27	1.46	2.33	1.48	2.01	1.29	2.67	1.54	2.42	1.46	2.17	1.19	56.5
ROAD	880	2.12	1.30	2.05	1.30	2.29	1.37	2.99	1.50	3.01	1.55	2.76	1.26	60.5
Means adjusted for the covariate (Lm, day)														
RAIL		2.45		2.50		2.16		2.88		2.61		2.33		
ROAD		1.98		1.91		2.17		2.82		2.86		2.63		

b) Annoyance / disturbances at night: The multivariate test shows again that the factor 'Source' is significant (F=50.0, p<=.0001). The univariate analyses with regard to the factor 'Source' show, that the annoyance due to road traffic noise is significantly higher than the annoyance attributed to railway noise. This is true for all variables considered (see Table 2): DN8: preventing from falling asleep (F=84.4; p<.0001); DN9: wakening up at night (F=61.6; p<.0001); DN10: wakening up in the morning (F=185.2; P<.0001); and: DNT: total disturbance at night (F=43.0; p<.0001). Considering these results one has to take into account that the variables DN8 - DN10 refer to *subjective* sleep disturbances, which are attributed by the *Ss* (when questioned) to the noise from each source. The analyses by which the (non-) correspondence between such subjective responses and objective indicators of sleep quality are investigated are not yet completed. - Similarly as during the day there is also a stronger tendency at night to close the windows for road than for railway noise.

Table 2. Response means and standard deviations (std) for each source (road / railway noise): at night

Source	N	DN8: preventing from falling asleep		DN9: wakening up at night		DN10: wakening up in the morning		DNT: total disturbance at night		Lm, night
		Mean	Std.	Mean	Std.	Mean	Std.	Mean	Std.	Mean
RAIL	708	1.89	1.26	1.60	1.08	1.50	1.01	2.13	1.29	60.1
ROAD	886	2.18	1.39	1.81	1.20	2.10	1.40	2.24	1.19	53.8
Means adjusted for the covariate (Lm, night)										
RAIL		1.68		1.44		1.32		1.95		
ROAD		2.35		1.94		2.24		2.39		

c) Annoyance / disturbance responses for day and night (without specification of time of day): As in the analyses described above, the multivariate tests show that the factor 'Source' is significant (F=22.5; p<=.0001). The multivariate test and the corresponding univariate tests for the factor 'Source' indicate that the total general annoyance / disturbance is significantly higher for road than for railway noise; this is true for 'GA: general annoyance' (5-point scale; F=33.4; p<.0001) as well as for 'TD: total annoyance/disturbance' (11-point scale; F=44.3; p<.0001). - 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 headache to a higher degree by road than by railway noise.

Table 3. Response means and standard deviations (std) for each source (road / railway noise): annoyance reactions without specification of time of day.

Source	N	GA: general annoyance		TD: total annoyance / disturbance at home		Lm, 24h
		Mean	std.	Mean	std.	Mean
RAIL	708	2.78	1.28	3.52	2.85	58.1
ROAD	886	3.20	1.28	4.61	2.98	59.2
Means adjusted for the covariate (Lm, 24h)						
Rail		2.82		3.63		
Road		3.17		4.52		

4. DISCUSSION

The results of the present study confirm on the whole the results from previous field studies (e.g. [3, 4, 5, 6]; for some conflicting results see [7]) and laboratory studies (e.g.: [8]). For example, Moehler et al [3] reported also greater annoyance due to road traffic noise (railway 'bonus') for variables like 'general annoyance' or 'sleep disturbances' and greater annoyance due to railway noise (railway 'malus') for variables referring to communication.

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% (related to the total number of trains passing in 24h). Different results may be obtained if one investigates the responses of residents living at railway lines with higher number of trains and where the proportion of high speed trains (like the TGV, the Shinkansen, or the ICE) or of freight traffic is very high.

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