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DETERMINATION OF TRAFFIC NOISE NUISANCE AS A FUNCTION OF TRAFFIC TYPE AND DENSITY IN A HEAVILY POPULATED AREA (STREET AND RAIL TRAFFIC)

G. Heimerl and E. Holzmann

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Translation of "Ermittlung der Belästigung durch Verkehrslärm in Abhängigkeit von Verkehrsmittel und Verkehrsdichte in einem Ballungsgebiet (Strassen- und Eisenbahnverkehr)" (source not given; summary of Report 13, Forschungsarbeiten des Verkehrswissenschaftlichen Instituts an der Universität Stuttgart, August 1978)

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16. Abstract

On the basis of a study including noise level measurements during the day and night and 1125 interviews with residents, it was found that railway noise creates less of a disturbance than street traffic noise. By far the largest majority of respondents experienced the greatest disturbance during the day. The difference in nuisance decreases as noise level rises.

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DETERMINATION OF TRAFFIC NOISE NUISANCE AS A FUNCTION OF TRAFFIC TYPE AND DENSITY IN A HEAVILY POPULATED AREA (STREET AND RAIL TRAFFIC)[1]

G. Heimerl and E. Holzmann

1. Formulation of Problem and Goals /1*

Constantly increasing mobility and the concomitant increase in traffic on the one hand, and the consciousness of the environment, on the other hand, which has come to be stronger than it was, make it necessary to give careful consideration to the importance of environmental protection while planning projects. The question of the anticipated noise nuisance is in the foreground when planning and building new land transportation routes.

To evaluate this noise nuisance it is necessary to research the connections between objective noise measurement and subjective noise perception at various noise intensities. Here the question arises how far there are variations in the evaluation of rail vs. road traffic noise in the sense of Sec. 43 of the Federal Emission Control Law (BImSchG) which might make it sensible to set variable evaluation standards and limits (one must take into account the peculiarities of rail traffic). To be sure, the physico-technical characteristics of road and rail traffic are well known, but neither in Germany nor abroad are there tests concerning both

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[1] Summary of formulation of task and results of a study performed 1976-1978 at the University of Stuttgart and supported by the Deutsche Forschungsgemeinschaft. Published in the series of research papers of the Verkehrswissenschaftliches Institut of the University of Stuttgart, Report 13, August 1978.

*Numbers in the margin indicate pagination in the foreign text.

rail and road traffic together, permitting a definite quantitative (or even merely qualitative) comparative statement on the nuisance effects of street and rail traffic noise.

The present study is to make a scientific contribution to the question of whether and to what extent the nuisances caused by road and rail traffic vary one from the other at the same noise emission (A-evaluated average level).

2. Execution of Study /2

To obtain the relevant empirical data for the study under the formulation of the problem and goal, a more extensive field study was necessary. For this, traffic was counted in selected study areas during the summer of 1976, and the noise was measured while at the same time the population involved was interviewed about the type and severity of the noise nuisance perceived.

The study areas lay in the heavily populated area of Stuttgart; the comparison areas for rail noise and road noise were similar to each other with respect to noise emission, buildings, vegetation, location with respect to the traffic route and population structure. Four rail noise areas and five road noise areas were chosen, as well as two mixed areas (with rail and road noise approximately equal). By expanding the interview zones as far as the second rank (greater distance from traffic route), we obtained additional gradations of the levels, so that there were seven stages of noise available for the evaluation of each rail and street noise area, and four stages for the mixed areas.

In the road noise areas the speed limit was 50 km/hr; in the rail noise areas it was between 80 and 120 km/hr.

In each measurement area the noise levels were continuously recorded for 24 hours (between Monday noon and Friday noon);

reading interval 1 hour. The evaluation criterion was the A-evaluated average level for the day (6 am - 10 pm) or night (10 pm - 6 am). The average day level was between 54.5 and 73.4 dB(A) for rail noise and between 57.3 and 73.2 dB(A) for street noise; average night level for rail noise was between 52.9 and 69.8 dB(A), and between 47.7 and 66.9 dB(A) for street noise.

The interviews included questions about not only noise and its nuisance value, but also social structure, contentment of the interviewee with his environment, attitude towards various means of transportation and their use, and questions about the physical condition of the interviewee. With the aid of a suitably extensive questionnaire (106 question complexes), which was first tested and then optimized on the basis of the tests, a total of 1125 evaluable interviews were gathered by 62 previously trained and constantly checked (15% of questionnaires) interviewers. /3

All results of measurements, counts and interviews were worked up by computer; evaluation was performed in the large computer facility of the Computer Center at the University of Stuttgart.

Nuisance perception was measured with a five-point scale (none/mild/average/severe/intolerable nuisance). It was necessary to test whether the gradations of this scale provide equal intervals; for this purpose, various evaluations of the scale distribution were tried. The differences between road and rail noise nuisances were unchanged.

Since by far the greatest part (85% of all mentions) of the nuisance reactions fell during the daytime (6 am - 10 pm), the statements under this scaling were referred to the day levels. To evaluate special nighttime nuisances, statements about difficulty in falling asleep or waking up at night were applied.

All calculations were first performed separately for road and rail noise, and then compared.

In the regressive calculations to determine the connection between noise level and nuisance, linear and non-linear expressions were tested. The linear connection between average level or peak level on the one hand and nuisance reactions on the other hand yielded the best correspondence. Different weightings of the noise elements were examined (passenger train, freight train, automobile, motorcycle, truck).

The influence of the varying differences between night and day levels for road and rail noise yielded no correlative connection with nuisance. In studying the different extents of variation between peak levels and background noise with rail and road noise, there was also no significant correlation with nuisance. The possible moderation variables tested in the context of this study presented no significant effect on nuisance perception.

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As a control, the evaluations were also performed for the case in which each area was eliminated once in turn from the total group of study areas. The results were hardly changed by this. This proves that the results are not affected by any areas that happened by chance to be badly chosen.

3. Presentation of Most Important Results

-- The difference between the average day level and average night level in the measurement area lay on the average around 2dB(A) for rail noise and around 9 dB(A) for road noise. The difference between average level and peak level was approximately 13 dB(A) for rail noise and approximately 10 dB(A) for road noise.

-- For both road and rail traffic the overwhelming majority felt bothered by noise all day (85% of all possible mentions).

-- The rail noise is felt to be less bothersome than street noise; this difference becomes less as the noise level rises. The absolute value of this difference was determined in favor of rail traffic during the day, being 7 to 10 dB(A) for road noise on a base level of 55 dB(A), and 5 to 6 dB(A) for a road noise level of 70 dB(A), as the two following parts show, in which the results are presented for the groups:

-- average + severe + intolerable nuisance

-- severe + intolerable nuisance.

Number of those disturbed (average, severe and intolerable)	Noise Level Road Noise L_{AmT}	Noise Level Rail Noise L_{AmT}	Difference ΔL
%	dB(A)		
50	55,0	62.6	7.6
64	60.0	67.1	7.1
77	65.0	71.7	6.7
86	70.0	76,3	6,3

Noise level differences (day level 6am - 10pm) for the same number of persons disturbed. (Groups: average + severe + intolerable nuisance).

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Number of those disturbed (average, severe and intolerable	Noise Level Road Noise L_{AmT}	Noise Level Rail Noise L_{AmT}	Difference ΔL
%	dB(A)		
26	55,0	65,4	10,4
36	60,0	68.5	8,5
47	65,0	71.7	6,7
59	70.0	74.8	4,8

Noise level differences (day level 6am - 10pm) for the same number of persons disturbed. (Groups: severe + intolerable nuisance).

-- The differences in perception of a nuisance are still greater at night than during the day. The numerical values on nighttime sleep disturbances (difficulty falling asleep and waking up at night) present a difference in noise level of over 11 dB(A) in the softer range (street = 50 dB(A)) with the same percentage of persons bothered. For the loud range (street = 65 dB(A)) this difference decreases to 9 or 6 dB(A), respectively.

Effects of Traffic Noise	Number Disturbed	Noise Level Road	Rail	Difference
		L_{AmN}	L_{AmN}	ΔL
	%	dB(A)		
Keeps one from going to sleep	21	5o	61,4	11.4
	32	55	65.8	1o.8
	43	6o	7o.2	1o.2
	54	65	74.5	9.5
Wakes one up at night	22	5o	61.5	11.5
	3o	55	64,7	9.7
	38	6o	68.o	8,o
	46	65	71.2	6,2

Noise level differences (Night level 10pm - 6am) with the same number of persons disturbed, measured by difficulty in going to sleep and waking up at night.

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-- The differences in perception of a nuisance between rail and street noise are distinctly greater for the peak levels than for the average levels. Among other things this disarms the occasionally heard view that a railroad would present a comparatively more severe nuisance because its peaks are more marked than with road traffic.

Nuisance Group

average+severe+intolerable				severe + intolerable			
Number of persons disturbed	Road L_1	Rail L_1	Diff. ΔL	No. of persons disturbed	Road L_1	Rail L_1	Diff. ΔL
%	- - - - db(A)	- - -		%	- - - - dB(A)	- - -	
Day values (6am - 10pm)							
62	65	79,8	14,8	35	65	81.6	16,6
70	70	82.8	12,8	42	70	83,4	13,4
78	75	85,7	10.7	50	75	85.3	10.3
85	80	88,7	8.7	57	80	87.1	7,1

Noise level differences with the same number of persons disturbed, based on a peak noise level L_1.

-- The study of individual effects of traffic noise confirm the aforementioned numerical results. In almost all cases the road traffic is more bothersome than rail traffic. In the soft range (55 dB(A)) the railroad hardly causes nuisance reactions. In the loud range (70 dB(A)) communication activities (physically and acoustically) are particularly disturbed by rail traffic, and the nuisance in listening to the radio or television is felt to be even more severe with the railroad than with street traffic; however, street traffic is particularly faulted because one cannot leave windows facing the street open.

The representativity of the 1125 samplings taken could be tested for the Stuttgart test area in the context of another representative interview; this showed throughout a high degree of agreement on all tested points (age structure, sex, education, family status, etc). It cannot yet be evaluated how far the statements on the study area can be generalized; however, there /7
are no plausible reasons to contradict the assumption that at least in West German population centers conditions occur similar to those in the Stuttgart area.

4. Summary

From the results of this work one can see that, using the A evaluation with identical measurement, sampling and calculation methods, one finds the same nuisance from road and rail noise at different noise levels, or that the same noise levels of road and rail noise are experienced as bothersome to a differing degree.

One can view the differing frequency spectrum and the different information frequency of rail and road noise, as well as the high component of quiet time with rail noise, compared to road noise, as significant reasons for this difference in nuisance value.

As long as the A-evaluated averaging level alone is used as the basis for a "hearing-correct" evaluation of noise -- and this will surely be maintained for the foreseeable future because of the international agreement reached -- then according to the present knowledge, the variable nuisance effect of street and rail traffic noise must be taken into account in determining noise pollution limits. For this, an added-amount method seems a possible solution. From the results of the present work the order of magnitude of these added amounts can be derived.