RAILWAY BONUS FOR SOUNDS WITHOUT MEANING?

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ABSTRACT

At same A-weighted energy-equivalent level, railway noise frequently is preferred to road traffic noise. This effect often is called railway bonus. Among possible reasons for the railway bonus, differences in spectrum, time structure, and meaning of sound are discussed. In order to largely "neutralize" the meaning of sound, a procedure was proposed as follows: the sound, e.g. railway noise, is analyzed by Fourier-Time-Transform (FTT) and - after spectral broadening – re-synthesized by inverse FTT. The procedure has the advantage that the loudness-time functions of original and neutralized sound are identical, but the meaning of the sound is removed. In psychoacoustic experiments, for original sounds of railway versus road traffic noise, a railway bonus could be ascertained. If for the same sounds, when deprived from their meaning, also a railway bonus would show up, then the meaning of sound would contribute to the railway bonus much less than differences in spectrum and/or time structure. If, on the other hand, the meaning of sound would be a dominant factor for the railway bonus, with neutralized sounds no railway bonus should show up. Results of corresponding psychoacoustic experiments are reported and discussed in view of the psychophysical method used.

KEYWORDS: road traffic noise, railway noise, railway bonus, neutralized sounds, noise immissions, meaning of sound

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INTRODUCTION

At same A-weighted energy equivalent level, railway noise is frequently preferred to road traffic noise. This effect often is called railway bonus (Möhler 1988 [11], Fastl et al.1994 [4]). Among possible reasons for the railway bonus differences in spectrum, time structure and meaning of sound are discussed (Fastl et al. 1996 [5]). Spectral differences between road noise and rail noise at low frequencies can account for part of the railway bonus: the low frequency components of road noise are strongly attenuated by A-weighting. However, these components contribute to the loudness of road noise and therefore, despite same A-weighted level, road noise can be perceived as being louder than rail noise (Fastl 1996 [1]). The temporal structure of rail noise with long pauses between events also could contribute to its preference over road noise, in particular for busy roads with densely packed events.

A third alternative put forward in the literature as a a possible cause of the railway bonus would be nostalgic feelings evoked by (howling) train sounds, leading to a preference of railway noise. This hypothesis was assessed as follows: a procedure was used which largely can “neutralize” the meaning of sound. Despite the fact that the loudness-time functions of original and neutralized sound are identical, the meaning of the sound is removed, i.e. the sound source can no longer be recognized.

In this paper, results of experiments are reported, in which original sounds as well as neutralized sounds were evaluated with respect to overall loudness or by a method of semantic differential. The results will be discussed in view of the following two questions:

(1) whether for neutralized sounds also a railway bonus shows up, and
(2) whether the recognition of specific sound sources like railways may influence the judgements.

EXPERIMENTS

Eight subjects with normal thresholds of hearing and an age between 24 and 58 (median 25) years participated in the psychoacoustic experiments. Sounds were presented in an anechoic chamber over a loudspeaker (Klein & Hummel O96) 1.5 meters in front of the subjects. Subjects were tested one after the other. Sounds presented had a duration of five minutes and were typical examples for noise immissions from road traffic noise or railway noise. Both sounds had the same energy equivalent A-weighted level of 55 dB(A).

In order to remove the meaning of the sounds, a procedure was used as follows (Fastl 2001 [2], Fastl 2002 [3]): The noise immissions of five minutes duration were spectrally analysed by an FTT procedure (Terhardt 1985 [12]), and - after spectral broadening - were re-synthesized by inverse FTT. The corresponding procedure is illustrated in figure 1.

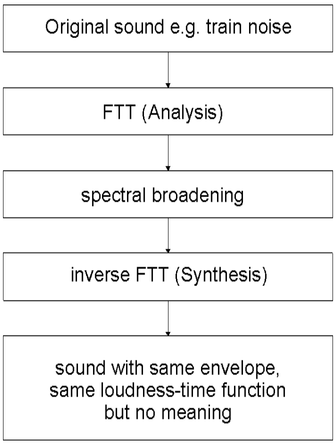

Fig. 1: Block diagram illustrating the procedure to neutralize the meaning of sound.

In this way, sounds were produced which have the same loudness-time function as the original sounds, but the information about the sound sources is removed (Fastl 2001 [2]). In essence, the neutralized sounds can be compared to amplitude modulated broadband noise.

With the four sounds of five minutes duration each, the following experiments were performed: (1) judgement of overall loudness by category scaling (Kuwano and Namba 1985 [8], Fastl et al. 1989 [6]); (2) evaluation by the method of semantic differential (Kuwano et al. 1997 [9]). Since both methods are described in the literature, for details the reader is referred to the references given.

RESULTS

Figure 2 shows the results obtained by category scaling of overall loudness. Seven categories from very soft to very loud are used. Filled symbols denote loudness judgements for road traffic noise, open symbols indicate loudness judgements for railway noise. Squares illustrate loudness judgements for original sounds, rhombs loudness judgements for neutralized sounds.

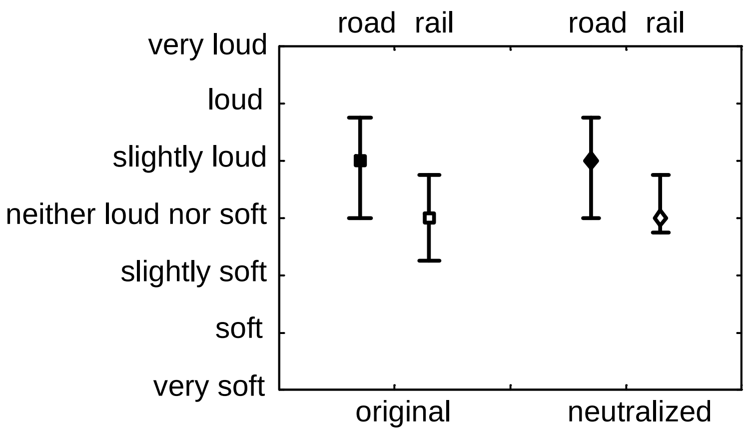

Fig. 2: Judgement of overall loudness for road traffic noise versus railway noise of five minute duration each with L_{Aeq} = 55 dB(A). Filled symbols: road traffic noise, unfilled symbols: railway noise. Squares: original sounds, rhombs: neutralized sounds.

The data displayed in figure 2 clearly show that despite the same A-weighted energy equivalent sound pressure level of 55 dB(A), railway noise is judged softer than road traffic noise (c.f. unfilled versus filled square). This result is in line with the concept of “railway bonus”. When the meaning of the sounds is neutralized (rhombs), also a railway bonus shows up, i.e. the neutralized sound derived from road traffic noise is judged louder than the neutralized sound derived from railway noise. Since the original sounds and the neutralized sounds show the same loudness-time function, but for the neutralized sounds the sound sources can no longer be recognized, the results displayed in figure 2 could be interpreted as follows: the loudness differences seem to be the main cause for the railway bonus and the meaning of sounds, e.g. the nostalgic feelings connotated to railway noise seems to be less important.

In order to get more detailed information about possible reasons for the railway bonus, noise immissions of five minute duration were evaluated by the method of semantic differential. A list of adjectives was chosen, which had been successfully used in an international study (Kuwano et al. 2000 [10]).

Figure 3 gives the results for the original sounds. Filled squares indicate data for road traffic noise, unfilled squares show results for railway noise. From the data displayed in figure 3 it becomes clear that in comparison to railway noise, road traffic noise is louder, more frightening, more dangerous, more powerful, etc. This result could be interpreted in favour of a “railway bonus”.

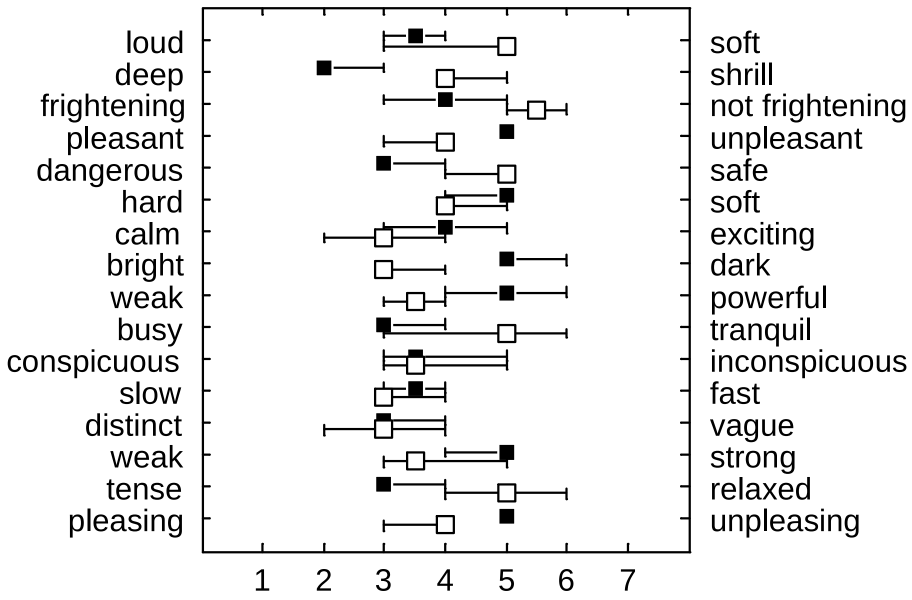

Fig. 3: Semantic differential for road traffic noise (filled squares) versus railway noise (unfilled squares).

Figure 4 gives the results for the corresponding neutralized sounds. Data for neutralized road traffic noise are indicated by filled rhombs, results for neutralized railway noise by unfilled rhombs. As for the original sounds, in comparison to the neutralized railway noise, the neutralized road traffic noise is louder, more frightening, dangerous, powerful etc.

These results indicate that also for neutralized sounds, a railway bonus shows up. Moreover, at first sight, these data could be interpreted that the meaning of sound does not influence the railway bonus.

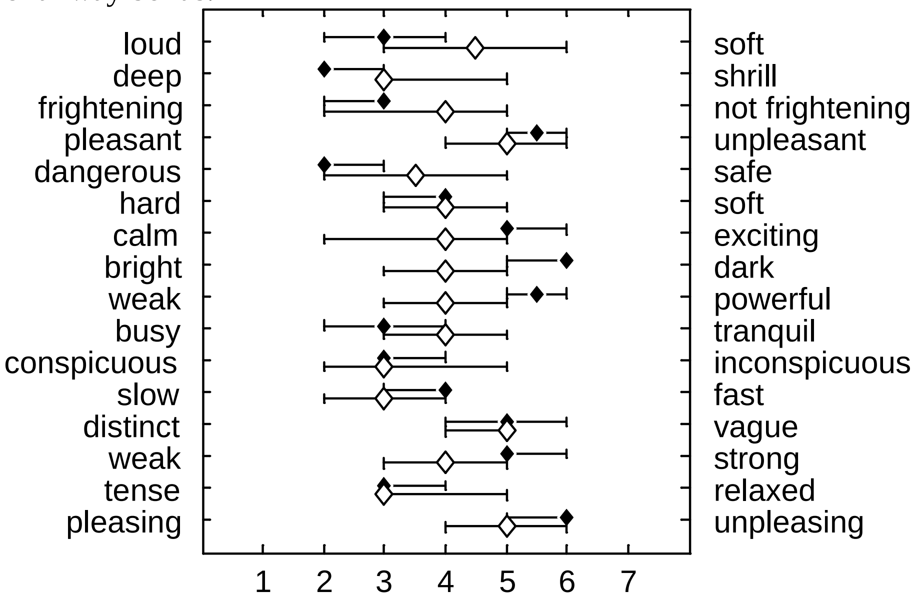

Fig 4: Semantic differential for neutralized road traffic noise (filled rhombs) versus neutralized railway noise (open rhombs).

Table I enables a closer inspection of the data. For both original and neutralized sounds, the statistical significance of the differences between road traffic noise and railway noise are given.

	original	neutralized
	road vs. rail	road vs. rail
loud/soft	**0.0185**	**0.0234**
deep/shrill	**0.0000**	**0.0017**
frightening/not frightening	**0.0197**	**0.0314**
pleasant/unpleasant	**0.0004**	0.1796
dangerous/safe	**0.0006**	**0.0298**
hard/soft	0.1400	0.1808
calm/exciting	**0.0147**	**0.0124**
bright/dark	**0.0000**	**0.0006**
weak/powerful	**0.0002**	**0.0002**
busy/tranquil	**0.0039**	**0.0145**
conspicuous/inconspicuous	0.9343	1.0000
slow/fast	0.2572	0.1742
distinct/vague	0.2268	0.4466
weak/strong	**0.0010**	**0.0004**
tense/relaxed	**0.0009**	0.1099
pleasing/unpleasing	**0.0001**	0.2373

Table I: Analysis of the statistical significance of differences between road traffic noise and railway noise for original sounds as well as neutralized sounds. Statistically significant differences ($p<0.05$) are given in bold.

The data displayed in Table I suggest the following conclusions: For both original sounds and neutralized sounds, road traffic noise produces statistically significant larger values than railway noise for the adjectives

loud
deep
frightening
dangerous
exciting
dark
powerful
busy
strong.

Both original and neutralized sounds show no statistically significant differences between road traffic noise and railway noise for the adjectives

hard
conspicuous
slow
distinct.

Most interesting are the adjectives

pleasant
relaxed
pleasing,

which indicate a statistically highly significant difference ($p<0.001$) between road traffic noise and railway noise for the original sounds, but <u>not</u> for the corresponding neutralized sounds ($p>0.10$). These results can be interpreted that the loudness of sounds represents a dominant feature for the description of the railway bonus. However, some influence of the meaning of the sound source cannot completely be ruled out, since for the original sounds, where the sound sources rail versus road are easily recognized, there is a statistically significant difference with respect to the pleasantness of the sounds. If however, the sounds are neutralized, the differences in pleasantness disappear. In essence this means that the recognition of a railway as a sound source may contribute to some extent to a better rating.

CONCLUSION

The results of the experiments described in this paper clearly indicate that differences in loudness of sounds with same A-weighted energy equivalent level constitute a main reason for the railway bonus (cf. Fastl 1996 [1]). This holds true for both original sounds and neutralized sounds. Moreover, this conclusion is reached by the evaluation of overall loudness as well as by the method of semantic differential.

However, data from the latter method also indicate that some differences in the pleasantness of road traffic noise versus railway noise may play a role. In other words, some effects of the image of the sound source with respect to the railway bonus are possible. Hellbrück et al. (2002 [7]), when comparing original with neutralized sounds, also reported data, which point in a similar direction.

In conclusion then, some influence of the image of the sound source on the railway bonus may be possible. However, further experiments are necessary to explore the magnitude of these influences in detail, in particular in comparison to the dominant loudness differences.

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additional references: http://www.mmk.ei.tum.de/noise.html

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