Is the railway bonus influenced by the directions of the sound sources?

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Introduction

At same energy equivalent A-weighted level L_{Aeq} rail noise usually is judged as less annoying than road noise. This effect was found in field studies (Möhler 1988) as well as in laboratory studies (Fastl et al. 1996) and is called railway bonus. On the other hand at same L_{Aeq} aircraft noise frequently is judged as more annoying than road noise, an effect termed aircraft malus (Taylor 1993, Fastl and Hunecke 1995). As one reason for the aircraft malus it is often assumed that sounds, which come from above a subject, might be particularly frightening. When accepting this argument it should be possible to reduce the railway bonus by presenting the road noise in front of the subject, but the rail noise from above. In this paper, results of experiments with original as well as "neutralized" sounds are described for presentation of both road and rail noise in front of the subject versus presentation of road noise in front, but rail noise above the subject.

Experiments

Since a detailed description of the related experiments is given in a previous paper (Fastl et al. 2003) only the most important features are mentioned here. Eight normal hearing subjects participated in the experiment. Sounds were presented in an anechoic chamber over a (hidden) loud-speaker (K&H O 98) either 1.5 m in front or 1.5 m above the subject. Sounds presented had a duration of 5 minutes and were typical examples for noise immissions from road traffic noise or railway noise; they had the same L_{Aeq} of 55 dB(A). Using the procedure described in detail in Fastl (2001), the sounds were "neutralized", i.e. by FTT analysis, spectral broadening and inverse FTT synthesis the sounds were processed in such a way that their loudness-time function was kept identical, but the sound source could no longer be recognized.

Results

Figure 1 shows the results for the situation that both, road traffic noise and railway noise, are presented in front of the subject.

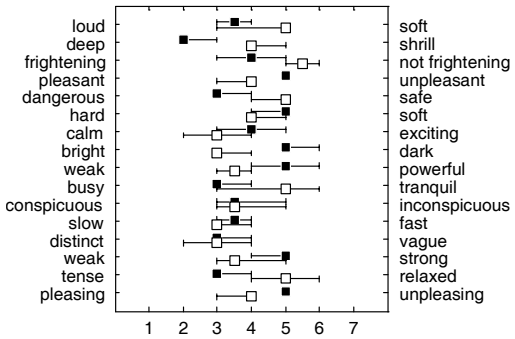

Figure 1: Semantic differential for road traffic noise (filled squares) versus railway noise (unfilled squares).

The data displayed in figure 1 clearly show the effect of "railway bonus": The road traffic noise is louder, more frightening, more dangerous, more unpleasant and so forth than the railway noise.

The data shown in figure 2 enable a comparison of neutralized road traffic noise and neutralized railway noise.

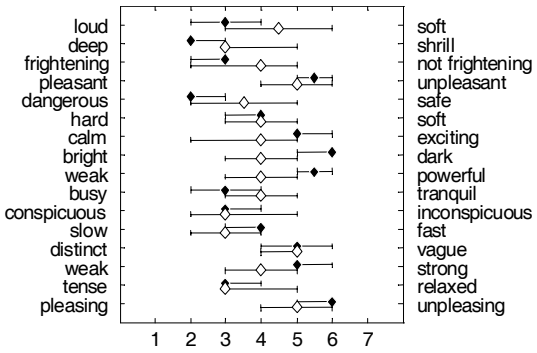

Figure 2: Semantic differential for neutralized road traffic noise (filled rhombs) versus neutralized railway noise (unfilled rhombs).

In Table I, for both original and neutralized sounds, the statistical significances of the differences between road traffic noise and railway noise are given. Bold figures indicate statistically significant differences which show up both for original and neutralized sounds with respect to the adjectives loud, frightening, dangerous, indicating – as expected – a railway bonus. For the adjectives pleasant or pleasing, statistically significant differences show up for original sounds, but <u>not</u> for neutralized sounds.

	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: Statistical significance of differences for both types of sounds presented in front of the subject

When the sounds are neutralized, differences in pleasantness disappear, and the recognition of a railway as sound source may contribute to some extent to a better rating.

Figure 3 shows the results for a different arrangement of the sound sources, i.e. road traffic noise presented in front, and railway noise above the subject.

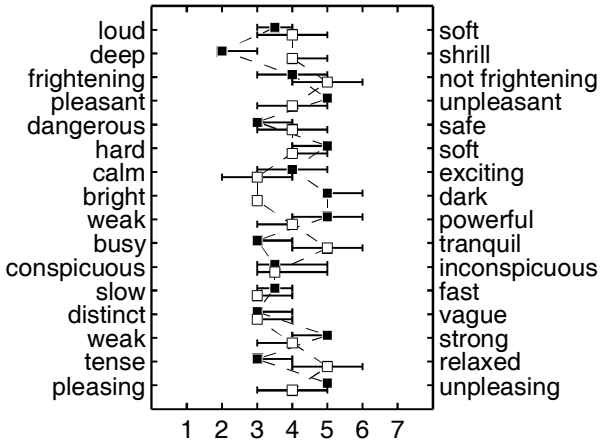

Figure 3: Semantic differential for road traffic noise presented in front of the subject (filled squares) versus railway noise presented above the subject (unfilled squares).

The data displayed in figure 3 indicate that for the presentation of road traffic noise in front of the subject and railway noise above the subject, the differences with respect to the adjectives loud, frightening or dangerous are smaller than for presentation of both sounds in front of the subjects (cf. figure 1)

Figure 4 shows the data for the related "neutralized" sounds. Also for the neutralized sounds there is little difference for the adjectives loud, frightening or dangerous between neutralized road traffic noise and neutralized railway noise.

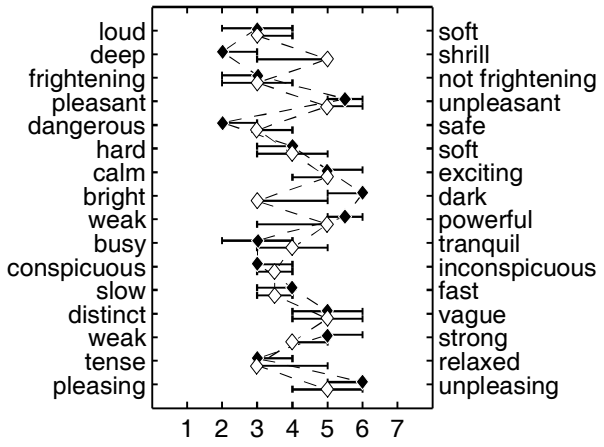

Figure 4: Semantic differential for neutralized road traffic noise presented in front of the subject (filled rhombs) versus neutralized railway noise presented above the subject unfilled rhombs).

As expected from the hypothesis put forward in the introduction, when railway noise is presented above the subject, the magnitude of the railway bonus seems to shrink.
The data displayed in Table II enable a closer comparison; they clearly reveal that for the case of presentation of road traffic noise in front, but railway noise above the subject, differences with respect to the adjectives loud or frightening are no longer statistically significant.
When comparing results for the adjective dangerous, according to Table I, the difference is highly significant (0.0006) whereas for the situation of road traffic noise in front and railway noise above the subject, the difference is only significant (0.0370). This holds for original sounds whereas neutralized sounds show no significant difference for the later form of sound presentation.

	road noise in front versus rail noise above	
	original	neutralized
loud/soft	0.1214	0.6439
deep/shrill	**0.0000**	**0.0000**
frightening/not frightening	0.0529	0.1215
pleasant/unpleasant	**0.0214**	0.5248
dangerous/safe	**0.0370**	0.0559
hard/soft	0.2718	0.5639
calm/exciting	0.0692	**0.0492**
bright/dark	**0.0000**	**0.0001**
weak/powerful	**0.0003**	**0.0002**
busy/tranquil	**0.0023**	**0.0078**
conspicuous/inconspicuous	0.8178	0.4698
slow/fast	0.6083	0.7547
distinct/vague	0.9323	0.9356
weak/strong	**0.0000**	**0.0009**
tense/relaxed	**0.0029**	0.4141
pleasing/unpleasing	**0.0081**	0.2072

Table II: Statistical significance of differences for road traffic noise presented in front and railway noise above the subject

Outlook

It could be shown that for presentation of sounds in front of the subject, for original as well as neutralized sounds the correlated semantic differentials are in favour of a railway bonus. If, however, road traffic noise is presented in front, but railway noise above the subject, the railway bonus shrinks to statistically insignificant values. These data seem to support the hypothesis that the aircraft malus maybe partly due to the fact that sound sources above the subject may be received as particularly frightening or dangerous.
In our next experiment we will compare road traffic noise presented in front of the subject with aircraft noise presented also in front or above the subject. Pursuing the argument put forward in this paper further, the aircraft malus is expected to be smaller for presentation of road and aircraft noise in front of the subject than for presentation of road traffic noise in front, but aircraft noise above the subject.
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