Effects of nocturnal railway noise on annoyance: Dose-response relationships from a field study in comparison to nocturnal aircraft noise annoyance

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INTRODUCTION

Traffic noise exposure during the night may disturb sleep and recreation inducing possible annoyance reactions of affected residents. Significant dose-response relationships between nocturnal aircraft noise and annoyance were confirmed, for instance, in a laboratory and a field study conducted by the DLR Institute of Aerospace Medicine (Quehl & Basner 2006). A common finding of studies on annoyance comparing different traffic modes is that annoyance ratings increase in the order railway least, road, and aircraft most (Miedema & Oudshoorn 2001; Miedema & Vos 1998). Based on these dose-response relationships a railway bonus was adopted in several European countries. The low impact of railway noise, however, was challenged by current investigations leading to the recommendation that the "rail bonus issue" has to be studied further (Gjestland 2008). In a recent laboratory study the effects of different traffic noise sources were compared with respect to sleep disturbance and annoyance (Basner et al. 2008). Although sleep disturbance increased in the order air, road, and rail traffic, it was found that annoyance reactions due to railway and road noise were equal and strongest due to aircraft noise. Since the validity of laboratory findings has to be proved in field studies the current study investigated the effects of nocturnal railway noise on sleep and annoyance of residents living in the vicinity of railway tracks in Germany. The present paper is focusing on annoyance and aims to compare the findings to the results of our field study on aircraft noise annoyance (Quehl & Basner 2006) providing a ranking of the two traffic modes with regard to night time noise annoyance.

METHODS

For the investigation of railway noise those railway lines of the Cologne/Bonn area were selected that bear a large quantity of freight train traffic during the night and where at the same time low road traffic was observed around. 33 subjects (22 women and 11 men) between 22 and 68 years ($M = 36.2$, $SD = 10.3$) participated in the field study. They lived between 0.7 and 29.6 years ($M = 5.5$ years, $SD = 6.0$) in their residences near the railway lines. During the daytime participants followed their normal course of life and could choose their bedtime individually with a compulsory sleep period between midnight and 6 a.m.

Acoustical measurements were carried out during nine consecutive nights at each site. Noise exposure was recorded indoors at the sleepers' ears by class-1-sound level meters (NC10, Cortex Instruments). The A-weighted energy equivalent noise

level (L_{Aeq}) and number of noise events (total number of trains, freight trains, and passenger trains) during bed time of each participant and each night were calculated.

Subjects rated annoyance due to nocturnal railway noise exposure in the morning by a questionnaire. A five-point scale ranging from 1 = "not" to 5 = "very" was used. Additionally, general annoyance previous to the study without referring to a special time of day and non-acoustical factors which could influence annoyance were evaluated by the participants once on five-point scales.

The results were compared with the results of a field study on aircraft noise which was conducted using identical methods in the vicinity of Cologne/Bonn Airport, an airport with high cargo traffic during the night (Quehl & Basner 2006). In that study 64 subjects (35 women and 29 men, mean age 37.4 years, $SD = 12.7$) were investigated.

RESULTS

General annoyance ratings previous to the study showed that more than half of the subjects (54 %) were highly annoyed (categories 4 and 5). With respect to nocturnal annoyance, however, which was evaluated every morning the percentage of all annoyance ratings in these categories covered only 2 %. Therefore, the analysis of dose-response relationships was based on the combination of ratings from moderate to high annoyance (categories 3-5) to a dichotomous dependent variable.

Dose-response relationships were established between nocturnal annoyance and the railway noise indicators L_{Aeq} and number of noise events (number of trains in general, freight trains, and passenger trains). For each of these acoustical variables a specific model using logistic regression analysis was calculated. No significant dose-response relationships were proved when only the acoustical variables were taken into account. Thus, non-acoustical factors were included in the model and the variables with the lowest impact were removed by a stepwise backward procedure. The final models were adjusted for subjective adaptation and length of residence. Again, annoyance increased only non-significantly, with rising L_{Aeq} ($\beta = .021$, $SE = .038$, $p = .584$). For the number of trains, however, a significant dose-response-relationship could be demonstrated ($\beta = .021$, $SE = .009$, $p = .018$). Furthermore, nocturnal annoyance rose significantly with growing numbers of freight trains ($\beta = .020$, $SE = .010$, $p = .048$), but not with passenger trains. Here just a trend was seen ($\beta = .044$, $SE = .024$, $p = .067$). With regard to the non-acoustical variables subjects who stated that they could better adapt to railway noise were less annoyed ($p<0.001$). Annoyance increased with longer time of residence nearby the railway lines ($p<0.05$).

The data of the field study on railway noise annoyance were compared to the findings of the field study on aircraft noise annoyance (Quehl & Basner 2006) in one logistic regression model. Based on the significant dose-response relationships calculated for aircraft noise annoyance the number of noise events per night (overflights respectively total number of trains) and the A-weighted energy equivalent noise level $L_{Aeq,\ event}$ measured indoors during bed time, where only those noise events exceeding 35 dBA had been taken into account were considered as noise indicators. In order to demonstrate a direct comparison between the effects of aircraft and railway noise only the acoustical factors without moderating variables were integrated in the regression models calculated for each indicator.

The results show that annoyance due to aircraft noise increased significantly with rising values of $L_{Aeq,\ event}$ ($p<0.001$) whereas the effect of railway noise on annoyance was smaller and not significant ($p=0.65$). Dose-response relationships based on predicted values from the regression model (Figure 1) indicate that annoyance is higher due to aircraft noise than due to railway noise. For example, the percentage of persons highly and moderately annoyed grew from a small percentage of approximately 4 % at 20 dB(A) to more than 40 % at the maximum of nearly 50 dBA for aircraft noise. The rise of annoyance due to railway noise, however, is hardly noticeable in the dose-response curve.

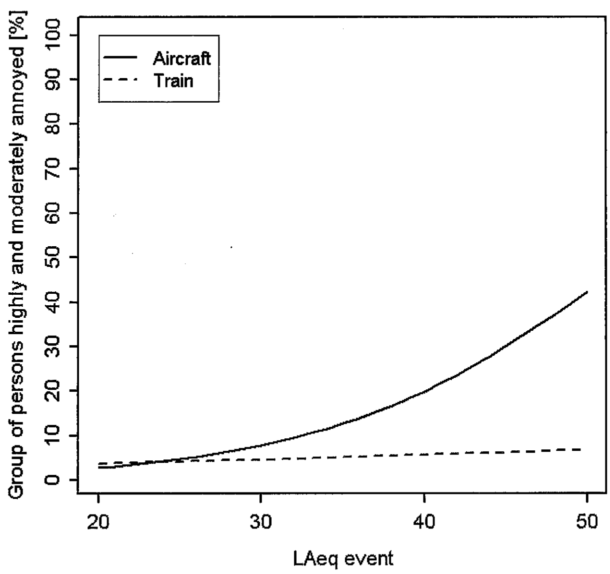

Figure 1: Predicted percentage of persons highly and moderately annoyed (categories ≥ 3) by aircraft and railway noise depending on the energy equivalent noise level $L_{Aeq\ event}$

Figure 2 illustrates the percentage of highly and moderately annoyed subjects depending on the number of noise events (nocturnal flyovers respectively trains). Annoyance due to aircraft noise increased significantly with rising number of noise events ($p<0.001$), and in this model non-significantly due to railway noise ($p = .15$). The dose-response curves show that annoyance due to aircraft and railway noise increased similarly up to 40 noise events per night. The percentage of persons annoyed by aircraft noise, however, rose up to about 68 % at the maximum number of flyovers of nearly 140. With the same number of trains the proportion of persons annoyed by railway noise was 18 % indicating a maximum difference of nearly 50 %. At 100 noise events per night, for instance, the percentage of people annoyed by nocturnal aircraft noise as predicted by the logistic regression model was over 30 % compared to approximately 10 % annoyed by the same number of trains. Furthermore, the curves for both railway noise indicators provide evidence for the higher relevance of number of trains compared to the energy equivalent noise level as shown in the regression models for railway noise alone.

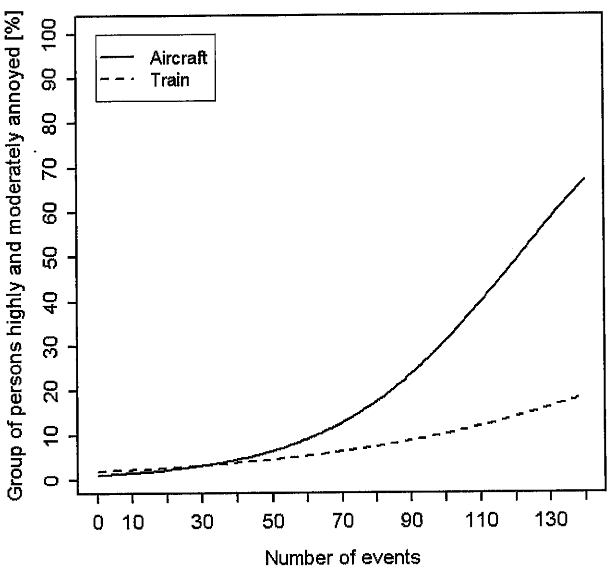

Figure 2: Predicted percentage of persons highly and moderately annoyed (categories ≥ 3) by aircraft and railway noise depending on the number of noise events

CONCLUSIONS

Dose-response relationships between nocturnal railway noise and annoyance ratings showed a significant increase of annoyance with rising number of trains, particularly freight trains, only if the regression model was adjusted for moderating variables. Subjects were less annoyed by the measured energy equivalent sound pressure level, since no significant effect was found. Furthermore, the data suggest that general annoyance judgements are mainly based on annoyance from traffic noise exposure during the day. A comparison with the effects of aircraft noise indicates lower nocturnal annoyance from railway noise than from aircraft noise at the same number of noise events and the same $L_{Aeq,\ event}$ measured indoors during bed time. Thus, the combined results from these field studies support the common ranking of rail and aircraft traffic in European countries with respect to annoyance.

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A survey on reaction of noise and vibration in construction sites

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ABSTRACT

86 % of disputes related with noise and vibrations were mediated by Ministry of environment and over 61 % of construction sites have suffered with noise complaint. Most noise complaints of construction sites are caused by construction equipment. In some countries, there are regulations to control noise level of construction equipment. The regulations classify construction equipment by 2 categories which are equipment subject to noise limits and equipment subject to noise marking only. However those kinds of regulations have limitation to reduce construction site noise and vibrations because various construction equipment were normally operated in construction site at the same time. And there is no clear guide line to control overall construction site noise. In this study, occurrence frequency and types of noise and vibration from construction sites were evaluated and types of complaint and reactions were analyzed.