Sleep disturbances caused by transportation noise – alterations of the polysomnogram

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Introduction

The influence of transportation noise is of growing importance because the volume of traffic increases gradually and causes a lot of primary and secondary effects on humans. Sleep disturbances are the most deleterious effects of noise which in turn influence performance and mood the next day [1,2].

The extent of disturbance is – irrespective of the equivalent sound pressure level (Leq) – determined by the source of noise. The metaanalysis of Miedema & Vos [3] shows that the percentage of highly annoyed persons grows with increasing equivalent sound pressure level. Comparing the three most important traffic noises (road, rail and aircraft), noise emitted from air traffic annoys more than road noise and the latter annoys more than rail noise. The difference between the sources of traffic becomes larger with increasing Leq (see figure 1).

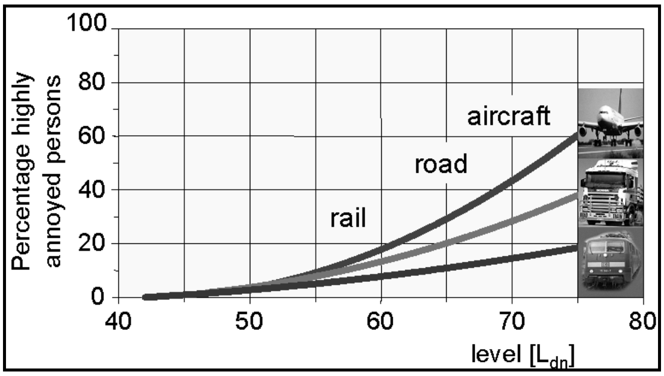

Figure 1: Percentage of highly annoyed persons as a function of DNL for aircraft, road traffic, and railway noise (modified after Miedema & Vos [3])

The present study, supported by the German Ministry of Education and Research, examines the effects of different modes of traffic noise on sleep, performance, and mood. The objective is to compare noises from road, rail and air traffic concerning sleep disturbances and after effects and to derive dose-effect-relationships concerning the maximum level and the equivalent noise level.

Methods

Subjects

The subjects for this experiment were 24 healthy and normal hearing students between the ages of 20 and 29 years. All 12 male and 12 female participants were matched with regard to their normal sleeping habits. 18 subjects were exposed to traffic noise and 6 subjects served as a control group.

Procedure

Each subject slept in the laboratory for 13 nights of three consecutive weeks. After an adaption night the students spent each week four successive nights from Monday till Thursday in the lab. The intermediate weekends were free.

In all the evenings the participants conducted a battery of four performance tests (switch task, simple and complex go/nogo task, random generation of numbers), which involve executive functions and filled in a questionnaire where they assessed their actual situation. Thereafter the electrodes for the polysomnogram (2 EEG, 2 EOG, 1 EMG) and the ECG were fixed. The records were recorded continuously throughout every night for eight hours. The polysomnogram is a clear indication whether a person is awake or asleep and provides reliable information on sleep depth.

During the nights from 11 p.m. till 7 a.m. the 18 students of the experimental group were exposed to transportation noise (road, rail and aircraft). Each week consists of three nights with equivalent noise levels of Leq =39, 44 and 50 dBA and one "quiet" night with a background noise of 32 dBA. The noise scenarios were presented in a permuted order.The same Leq for the three traffic sources was achieved by varying the number of events. The 6 subjects of the control group received only a 32 dBA continuous broadband noise throughout each night.

Every morning after being woken the participants assessed the qualitative and quantitative parameters of sleep by means of a questionnaire. Hereafter they completed the performance test battery again (figure 2).

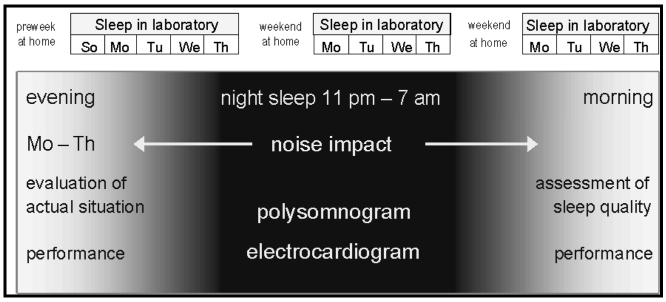

Figure 2: experimental design of the study

The present analysis concerns the alterations of the polysomnogram which was evaluated in accordance with the general criteria suggested by Rechtschaffen and Kales [4]. The specified sleep parameters are

- sleep latency (in minutes)
- total sleep time (TST, with intermediate periods awake in minutes)
- pure sleep time (PST, without periods awake)
- sleep efficiency index (PST / TST)
- amount of stage 3 (in percent)
- amount of REM sleep (in percent) and
- amount of intermediate time awake (in percent).

Results

The results are subdivided into two parts and based on the analysis of variance with repeated measurements.

Comparison -exposed and non-exposed persons

The evaluation reveals trends respectively significant main effects between the nine nights of exposed persons and the corresponding nights of non-exposed persons concerning latency, stage 3, total sleep time and amount of awake (table 1).

Sleep parameter	quiet	noise	p-value
Latency	15,82	25,30	.078
Stage 3	9,93	7,73	.026
REM sleep	22,03	21,36	.680
Total sleep time	463,26	453,54	.085
Pure sleep time	432,71	415,55	.114
Sleep efficiency index	0,934	0,915	.306
Awake	9,65	13,34	.099

Table 1: means and p-values of exposed and non-exposed persons for several sleep parameters

Comparison of sound pressure level conditions

Concerning the noise level a main effect was only obtained for the sleep efficiency index (p =.005; figure 3). For this sleep parameter significant differences were observed between the "quiet" 32 dB(A) condition and all the noisy conditions (39 dB(A):p =.003; 44 dB(A): p =.022; 50 dB(A): p < .00). Additionally the differences between the quiet and the loudest conditions revealed at least borderline significance for REM sleep (p =.009), stage 3 (p = .075), amount of time awake (p = .023) and pure sleep time (p = .018) is also significant respectively a trend. Total sleep time and latency were not affected.

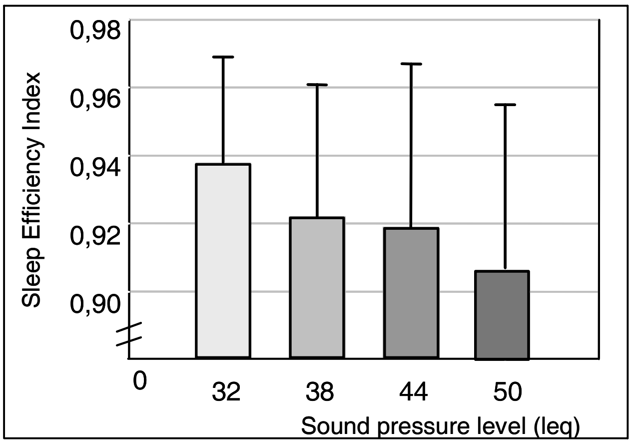

Figure 3: Comparison of sound pressure level conditions concerning the sleep efficiency index

Discussion

Nearly all sleep parameters calculated here were affected by traffic noise. Persons exposed by transportation noise fell asleep later, had a lower sleep depth, a reduced sleep time and an increased amount of time awake.

Irrespective of the type of traffic noise the sleep efficiency index decreased with the sound pressure level. For the other parameters (except total sleep time and latency) differences exist between the quiet and the loudest condition.

Overall, transportation noise caused alterations of the polysomnogram in terms of sleep disturbances.

The results presented here are preliminary. The whole sample of subjects consists of 24 persons exposed to noise and 8 subjects that constitute the control group. The evaluation of the EEG is in progress and the analysis of the whole sample also concerns the difference between the three modes of traffic noise. As the brain is able to perceive, to analyse and to respond adequately to various stimuli it is supposed that – according to Miedema and Vos (3) – aircraft disturbs most and rail noise the least.

References

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