Nocturnal noise from different sources and sleep disturbances – best practice, background and gaps in knowledge –

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Introduction

It is undisputed in noise effect research, that an effect-orientated summary of sound levels for exposed persons is urgently needed in order to judge complex noise situations correctly with regards to well being or health (Acceptor approach). This also applies to nightly noise exposure and its adverse effects on sleep. The data available for source-related sleep disturbances is however modest by comparison with “noise annoyance” and integrated energy indices are only restrictedly suitably for an effect-orientated assessment.

Sound Exposure indices

Different sound indices have been used to describe the noise-exposure. There is no general agreement as to which indices should be preferred. Integrated energy indices (LAeq, LDEN, Lnight), give a good overall description of global noise exposure, useable for daytime or 24-hour exposure, while event indices (LAmax, Sound Exposure Level: SEL, Number of Noise Events: NNE) would be more practical to predict effects of nightly noise.

Tabel 1: Three of the most prominent reviews regarding the effects of traffic noise on sleep (according [1])

Authors	**Year**	**Number of studies**	**site**
Lukas	1975	13	Lab.
Griefahn	1980	10	Lab.
Hofman	1994	53	Lab and field
Authors	**Type of noise**	**Noise exposure measures ***	**Effects**
Lukas (Lu)	Aircraft, sonic boom, road traffic	L_{Amax}, EPNL, SENEL	Awakening, arousal and no sleep disruption
Griefahn (Gr)	Aircraft, train, white noise, tones, road traffic	L_{Amax}	Awakening, 0-reaction
Hofman (Hof)	Aircraft, road traffic, train, industry	L_{Amax}	Awakenings, sleep stage changes

L_{Amax}: maximum A-level; PNL: perceived noise level; EPNL: effective perceived noise level; SEL: sound exposure level; SENEL: single-event noise exposure level.

A review of the literature shows that the majority acknowledged that the measures of maximum sound level are better predictors of disturbances in sleep than measures of average sound level [2, 3, 4].

Several attempts have been made to summarize results regarding maximum sound levels from different published traffic noise studies. Table 1 presents three of the most prominent reviews.

Nocturnal awakenings

In most noise studies the sleep disturbance would be quantified by nocturnal awakenings and therefore awakenings are practicable for assessing nocturnal noise exposure from different sources. The noise threshold for awakenings depends on several factors. It depends on the sleeper’s age, the current stage of sleep, and depends mainly on the acoustical information of the stimulus. The awakening threshold also depends on physical characteristics of the noise and the noisy environment (e.g. a sharply raising noise as well as a low background noise is particularly more disturbing). Therefore, experimental awakening thresholds are different for the some maximum sound level and different between unlike noise sources. In the reviews – mentioned above - different noise sources have been mixed together. It is obvious that the first step is to sort the findings regarding unlike noise sources, to get an impression of the awakening threshold related to sources. In figure 1 the findings regarding aircraft noise are presented. In addition to the literature in table 1 the results from the German DLR study (interims report) [5] is drawn in.

aircraft noise

Between published examinations for the same maximum level the findings for aircraft noise show wide differences in the probability of awakening. The differences between the findings could be reduced if the age of the sleeper and (the most unknown) situational factors were taken into account. Another well known source of variance is the number of nightly noise events. The strong influence of the number of events was mentioned by noise effect researchers in the past (e.g. [6]) and can be demonstrated by findings of the German DLR study, witch fit the data cloud in figure 1 quite well and by cortisol-related calculation published by Spreng [7]. With the DLR-curve in figure 1 every maximum sound level between 50 an 80 dB(A) can be translated into a respective probability of awakening. If we want to avoid a nightly risk of one noise-induced awakening per night (100% probability of awakening) it is possible to reduce the number of flights to an amount with an overall probability for awakening just beneath 100%. This amount of flights just beneath an acceptable risk is called “tolerable” flights. Tolerable flights to avoid one noise induced awakening are given in figure 2 regarding the DLR-curve.

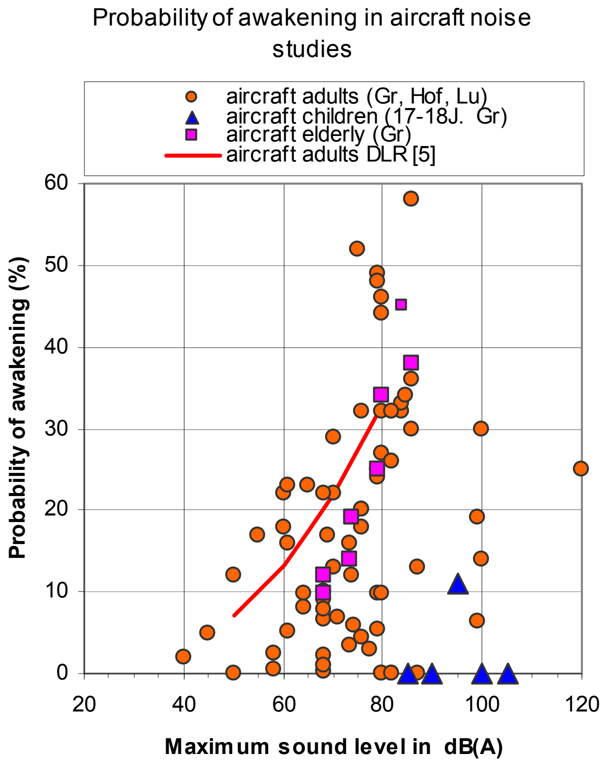

Figure 1: Probability of awakening in aircraft noise studies**.** Represented are mean group values which were published for the respective examination.

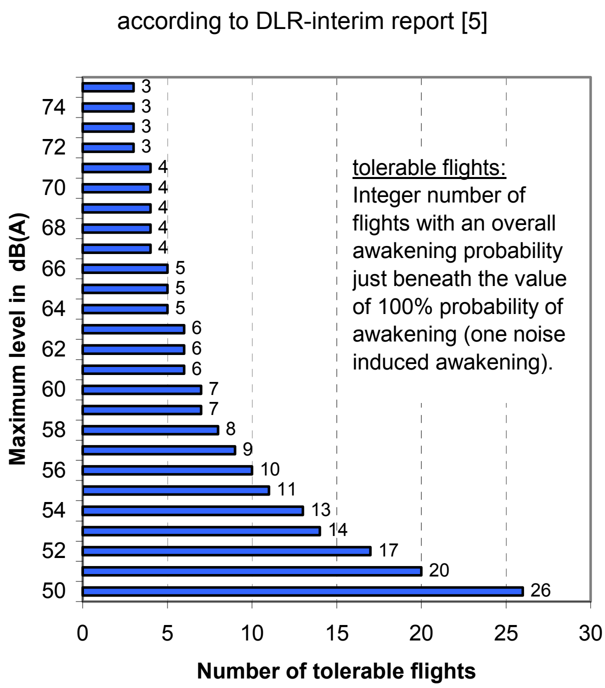

Figure 2: Tolerable flights to avoid one noise-induced awakening. The average number of not noise-induced awakenings was taken into account by the calculation of tolerable flights.

Discussion

The amount of tolerable flights in figure 2 shows that the same noise-induced risk of sleep disturbance (awakening) could occur due to a few events with high maximum levels (e. g. 3 events with Lmax = 72 dB (A)) as well as by a great amount of events with lower maximum levels (e. g. 26 events with Lmax = 50 dB (A)). The amount of nightly events as well as the maximum levels must therefore be taken into account to assess the noise-induced nightly risk. Furthermore, a meaningful assessment is not possible regarding the energy equivalent sound level. For example, with a fixed 10 dB down time of 20 sec for each noise event the equivalent sound level is 42.2 dB (A) for 3 events with Lmax = 72 dB (A) and 29.6 dB (A) for 26 events with Lmax = 50 dB (A).

To assess the nightly noise exposure from different sources regarding sleep disturbances it is necessary to keep in mind that different sources could produce different risk by the same maximum sound level because of different physical and social characteristics. It is a gap in noise research that we have few findings regarding the effect of maximum sound levels by road traffic noise and rare findings regarding the effect of maximum sound levels by train noise.

Conclusions

For an effect orientated assessment of the nightly sound exposure from different sources it is necessary to take into account the maximum sound levels as well as the amount of nightly noise events. An indicator for the combined nightly noise exposure could be built if we had reliable number-related probabilities of awakenings for different noise sources.

References

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