

Sound quality in offices - quietness versus privacy

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Abstract

In Germany, the noise in offices in which mentally demanding tasks are performed, must not exceed an A-weighted energy-equivalent level of 55 dB(A). In the framework of a larger study, the noise climate in a number of open plan offices has been investigated. It was found that open plan offices which are rated "quiet" show on the average a percentile loudness of $N_5 = 5\text{sone}_{\text{GD}}$ corresponding to pink noise of about 44 dB(A). In "loud" offices, the loudness is at least a factor of two larger and workers can be annoyed by the background noise, reducing their performance. On the other hand, in "quiet" offices the content of telephone calls of colleagues can be easily understood, reducing the privacy. Results of speech intelligibility tests suggest that optimum privacy is obtained only at unacceptably loud background noises.

1. Introduction

In Germany, in offices in which mentally demanding tasks are performed, the A-weighted energy-equivalent level must not exceed 55 dB(A). In this paper, this limit is discussed from two points of view:

1. The perceived quietness by workers in open plan offices with different noise climate.
2. The conflicting issues of quietness on the one side, and privacy on the other side.

The quietness of offices is assessed both in subjective and physical evaluations and a target value for a "quiet" office is proposed. In addition, requirements to achieve privacy in an open plan office are discussed.

2. Experiments

Since the details of the experiments have been described in a previous paper by Stemplinger and Seiter [1], only some important features will be reported here. In sixteen open plan offices, recordings of the noise climate were performed on DAT-tape for a duration of about thirty minutes. The microphone was in a position of an (absent) worker. Since the setup for the recordings may influence the usual workflow in an office, a "settling time" of ten minutes was excluded until the "normal" noise climate was reached. From the remaining 20 minutes recording typical sequences of five minutes duration were edited.

Nine subjects with normal hearing and an age between 24 and 37 years participated in the experiments. Sounds were presented diotically via headphones with freefield equalizer [2]. For the study on quietness, after five minutes of sound presentation, the subjects had to fill in a questionnaire indicating overall loudness by the length of a line. This questionnaire has proven successful for experiments of noise imissions previously (e.g. [3], [4]). For the experiments on privacy, a German rhyme-test [5] was used. In essence, the percentage of correctly identified items gives an indication of the correlated speech intelligibility.

The physical analysis of the sounds was performed by a sound level meter according to IEC 681 as well as a loudness analyzer [6] with statistics analyzer.

3. Results and Discussion

Figure 1 shows the loudness evaluation of open plan offices which were considered by the workers as "quiet". For the offices "a" through "j" the subjective evaluations are given by circles and bars indicating the medians and interquartile ranges of the line length (LL) indicated by the subjects. The correlated physical evaluation by percentile Loudness N_5 is represented by the crosses.

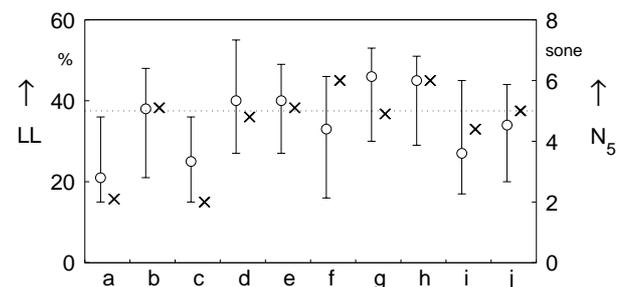


Figure 1: Subjective and physical evaluation of the loudness of offices considered by their workers as "quiet".

The results displayed in Figure 1 indicate that there is fair agreement between subjective evaluation (circles) and physical evaluation (crosses). For a "quiet" office, a percentile loudness of $N_5 = 5\text{sone}_{\text{GD}}$ seems to be typical.

Assuming for the sake of simplicity that the noise would be a pink noise, a loudness of 5 sone would correspond to about 44 dB(A), a value well below the 55 dB(A) limit.

Figure 2 shows results for offices which were labeled by the workers as "loud". Again usually there is agreement between subjective (circles) and physical (crosses) evaluation. However for sound "C" and in particular for sound "F" the subjective evaluation is significantly lower than the physical evaluation.

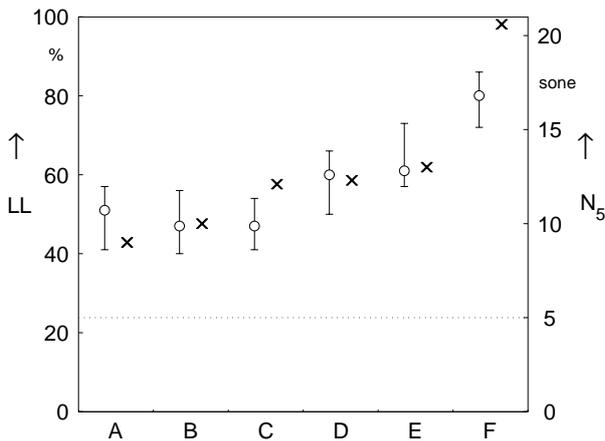


Figure 2: Subjective and physical evaluation of offices considered by their workers as being "loud".

For sound "C" the dominant sound source is a ringing telephone, and sound "F" was recorded in a chemical lab, in which however several doctoral students write their doctor's thesis and therefore they use it like an office. This special situation may have influenced the subjective rating that the students thought that in the context of a chemical lab, their "office" is considered as being not so loud. In all "loud" offices, the 5 sone limit is exceeded by at least a factor of two.

To assess the effects of privacy, two offices, a "quiet" ($N_5 = 4.7$ sone_{GD}) and a "loud" ($N_5 = 9.6$ sone_{GD}) one were considered. In the "quiet" offices we often get complaints from the workers that they easily can understand the conversations of their colleagues, and therefore feel massively disturbed in their work.

In order to achieve sufficient privacy, the intelligibility of the rhyme-test according to Sotschek [5] should be at or below 50 % of correctly identified items. In the "quiet" office, the 50 % limit is reached for a speech level of 37.6 dB, corresponding to a loudness of 2.06 sone_{GD} or a loudness level of 50.4 phon_{GD}.

In the "loud" office, for 50 % speech intelligibility, a speech level of 47 dB, corresponding to a loudness level of 62.2 phon_{GD} and a loudness of $N = 4.65$ sone_{GD} is necessary.

These results indicate that sufficient privacy can never be reached in "quiet" offices, because a speech level of

only 37.6 dB is quite unrealistic. Even for the example of a "loud" office, the required speech level of 47 dB will be exceeded in many practical cases, violating the desired privacy.

If on the other hand we look for a case, where privacy could be achieved, an interesting value would be the 70 dB(A) which are the limit for mechanistic work, which does not require so much concentration. Again assuming that the noise would be a pink noise, the 70 dB(A) correspond to a loudness level of 89 phon_{GD} and a loudness of about 30 sone_{GD}. This means that in a place where the loudness of 30 sone_{GD} is by a factor of 6 larger than the suggested limit of 5 sone_{GD} for a "quiet" office, sufficient privacy may be ascertained. In turn this means that under realistic conditions, in "quiet" open plan offices privacy is never attained. On the other hand, privacy may be ascertained under circumstances where the noise climate is unacceptable for mentally demanding work.

4. Acknowledgements

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5. References

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