Communication Behaviour and Workload of Students and Teachers in Highly Absorbent Classrooms

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"Lernen statt Lärmen e.V.", initiative against noise and for better ergonomics in schools

Summary
This lecture refers to an interdisciplinary research carried out in 2000 to 2006 at the Bremen University, Germany. A mixed team of acousticians, occupational and medical scientists and pedagogues investigated the kind of work and communication behaviour in synchronization with the classroom acoustic measurements in two elementary schools. First school had 4 classrooms with "very good" acoustics and 4 rooms with "good" acoustics, assessed by STI (speech transmission index). At the second school the acoustics of one classroom has been approved from "good" to "very good".
Differences of classroom acoustics are discussed appropriately. Based on observations of 175 lessons there will be discussed the effects of room characteristics (e. g. increased absorption, shortened reverberation time and improved speech intelligibility) on basic and working sound level in the context of each kind of work. A methodical examination of the database allows an assessment of mean values but also of the detailed teaching phases, as characterized by certain pedagogical factors. Therefore, it is possible for example to evaluate the effects of frontal lessons in contrary to differentiated lessons. The results provide the basis for discussions on stress level and work demands of teachers. It has been proved, that the heart rates of teachers are coupled to the stress reaction to the noise level. Student will show the same reaction. By monitoring all actions of teachers and students during the lessons it is now possible to analyze further on the impact on social behaviour depending on the acoustical conditions of classroom working.

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1. Introduction

Are schools too noisy? What is the reason that for and are there any potentials to reduce noise? To give answers to these questions the Inst. of interdisciplinary school research (ISF) at the University of Bremen started in 2000 a research project for 6 years at different schools [1][2]. The data of 2 elementary schools will be used for this presentation. The first school had 4 classrooms with "very good" acoustics and 4 rooms with "good" acoustics, at the second school the classroom acoustics has been improved from "good" to "very good" by refurbishment. Based on observations of 175 lessons there will be discussed the effects of room characteristics (e. g. increased absorption, shortened reverberation time and improved speech intelligibility) on basic and working sound level in the context of each kind of work. Especially at the 2nd school it's very simple to show the difference between "good" and "very good" acoustics, for the pupils, the teacher and the time table are the same for both weeks for monitoring the lessons.

Basic data for all analyses made are more than mean value of SPL, there are continuous and synchronous time series of basic and working SPL, each kind of work, detailed teaching phases, differentiated phases of speech by teacher or students and workload of the teacher by measuring the heart rate as very sensitive indicator for stress.

2. Stressor „Noise"

Noise is more than a SPL measured in Decibel; it's the result of an acoustic perception and cognitive

process. You will find very different descriptions of this cognition.
"One day humankind has to fight noise adamantly like cholera and pest." (Robert Koch, 1843-1910) or "Noise is the most significant hazard incident". It's not only a disruption; it's more than a separation of thinking." (Arthur Schopenhauer, 1788-1860). On the other hand you will find a song "What a beautiful noise" (1976 by Neil Diamond, *1941).

So we have two antipodal perceptions of "noise" for the same measured value of SPL. In both cases the physiological process is identically, it's a typical stress reaction depending on the strength of the signal, e.g. increasing of heart rate and blood pressure, but with different emotional reactions. Cognitive processes will be interjected and attention directed to the acoustical source. Hearing music will be a high emotional process and well favoured by the audience. Other types of acoustic occurrences during cognitive activities will interrupt this process. The longer these disturbances last, the shorter is the recovery time for attention. Consequence of reducing recovery time is increasing of fatigue and decreasing of attention.

A typical teacher's reaction, measured by heart rate (HR), on the noise in classroom during a lesson is shown in Fig. 1. Increasing of SPL generates increasing of HR, the same for decreasing of SPL.

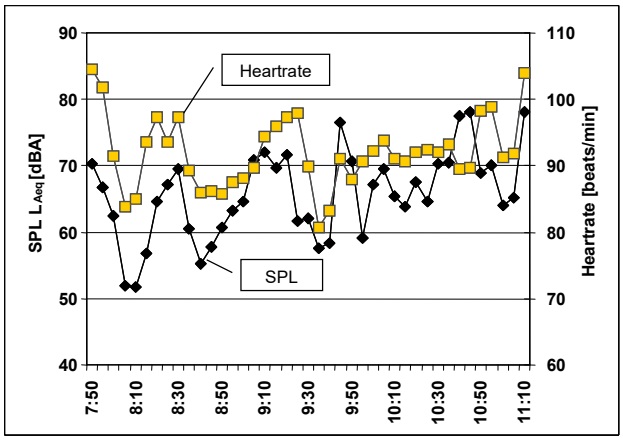

Figure 1. Heart rate of teacher and working SPL in classroom (Mean values of 5min time slices)

In workload research HR is used as an indicator for stress intensity. So Fig.1 shows the direct effect of noise, in this case of student's activities, on workload of teachers, similarly for students. But the intensity of reaction depends on room acoustics of the classroom, shown in Fig.2. At first the teacher's physiological reaction on noise in two different situations, under "good" and "very good" room acoustics in the classroom and identically teaching situations.

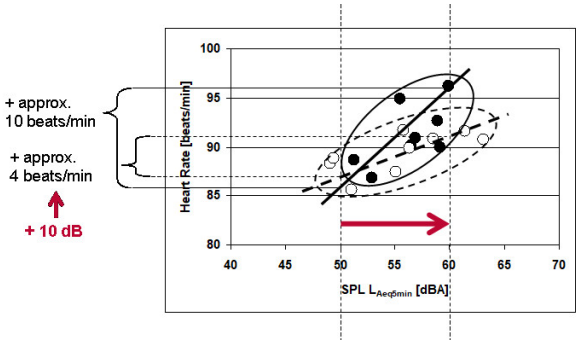

Figure 2. Heart Rate reaction on noise of the teacher, before and after acoustic refurbishment of the classroom.
● "good" , ○ "very good" room acoustic [2]

Fig. 2 shows the increase of heart rate as reaction of increasing SPL for 10 dB, under "good" conditions approximately 10 beats/min and under "very good" room acoustics only 4 beats/min. The lower physical stressor noise causes a lower physiological stress reaction. So it's a more human working condition.

One effect of fatigue is an increasing sensibility to noise, that means comparing subjective SPL rating on a fixed scale with objective measured value of SPL. The result for nine teachers is shown in Fig. 3. This is a typical reaction of people on undesirable noise.

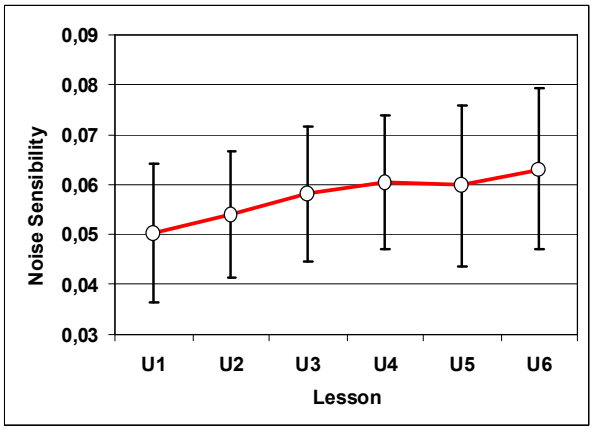

Figure 3. Increasing "Noise Sensibility" [3]

What about the "basic noise level" in classrooms over 5 lessons in the morning under different

acoustic conditions? Fig. 4 shows the increasing basic SPL in the classroom with "good" acoustic over fife lessons in the morning. After refurbishing to "very good" acoustic under identical pedagogical conditions there was measured nearly the same value of basic SPL over all lessons (2nd school).

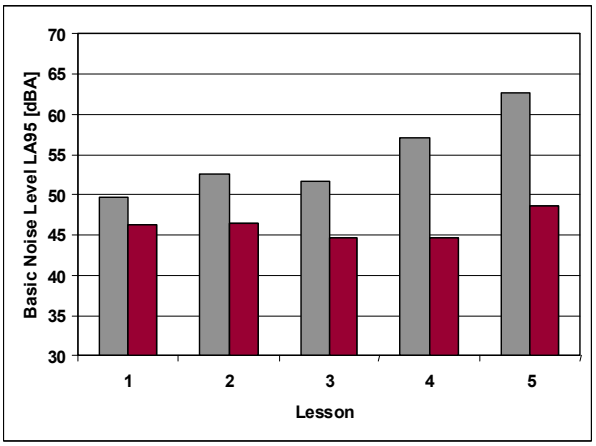

Figure 4. Basic Noise Level over all lessons in the morning, ■ "good" , ■ "very good" room acoustic

With "good" acoustics in a classroom "working noise" will increase on "Lombard Effect" and becomes more and more a stressor with increasing fatigue and decreasing concentration. With "very good" acoustics breaks between lessons are long enough for recreation; there is no increasing of SPL. Reduction of noise in classroom also produces better speech intelligibility, less fatigue and more power of concentration. That means in summery better learning conditions.

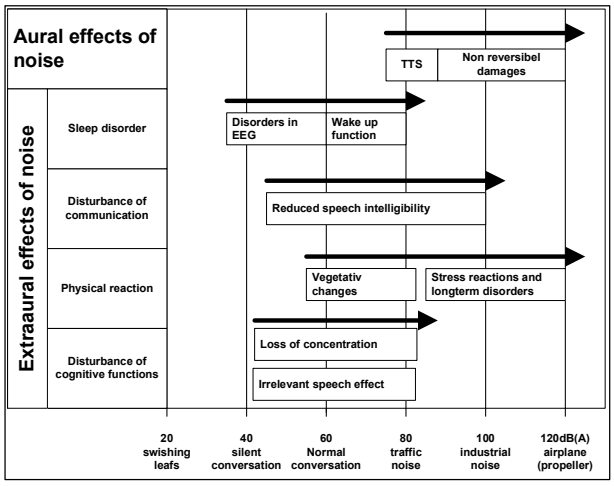

Figure 5. Overview about aural and extra aural effects of noise. According to: Lexikon der Psychologie [4] (translation by the author)

Effects of noise on human are mostly described as non reversible damages of the internal ear. This is only valid for SPL > 85 dB over more than 8 hours a day. In classrooms we monitored SPL from 55 dB to 75 dB, measured as L_{Aeq} for a lesson from 45min. Here are the extra aural effects of noise like “disturbance of cognition”, “physical reactions” and “disturbance of communication” more important as shown in Fig. 5. In contrast to standard classrooms are sport halls, where we measured SPL up to 88 dB as L_{Aeq} for a 90min lesson with peak values up to 105 dB. For these situations it’s absolutely necessary to use ear protectors, but this is in opposition to the pedagogic intention and safety of the working situation.

3. Conclusions

Noise is one of the most important stressors for human being. Evolution of human ear and hearing competence happened under very quiet environmental conditions that mean SPL between 40 and 60 dB. Today our “normal” living conditions are nearly 20 dB louder. There was not enough time to compensate this by an evolutional adaptation.

This is the reason, why it is necessary to lower noise in classrooms and similar rooms to create a very good environment for all people working inside without noise induced stress.

Acknowledgement

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