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Classroom Acoustics and Impact on Health and Social Behavior

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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 an pedagogues investigated the kind of work and communication behavior in synchronization with the classroom acoustic measurements in two elementary schools. One school had 4 classrooms with “very good” acoustics and 4 rooms with “good” acoustics; at the other school the classroom acoustics has been improved from bad 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 behavior depending on the acoustical conditions of classroom working..

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1. Introduction

Are schools to 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 "bad" 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 second school it's very simple to show the difference between "bad" 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 an 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 acoustical source. Hearing music will be a high emotional process and well favored by the audience. Other types of acoustic occurrences during cognitive activities will interrupt these process. The longer these disturbances last, the shorter are recovery time for attention. Consequence of reducing recovery time is increasing of fatigue and decreasing of attention.

At first the teachers physiological reaction on noise in two different situations, under "bad" and "very good" acoustics in the classroom, identically teaching situations.

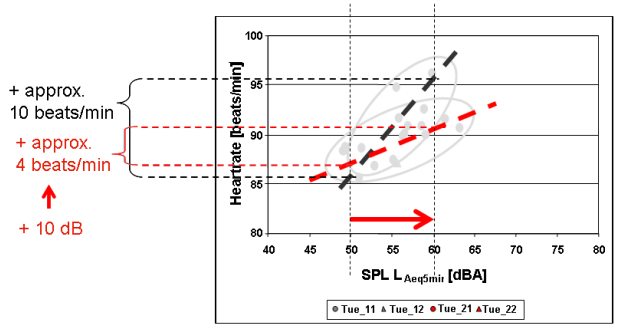

Figure 1. Heart Rate reaction of the teacher,
■ "bad" , ■ "very good" room acoustic

Fig. 1 shows the increase of heart rate as reaction of increasing SPL for 10 dB, under "bad" 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. 2. This is a typical reaction of people on undesirable noise.

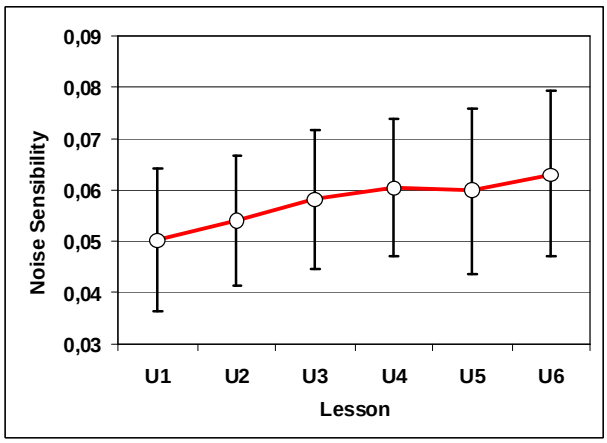

Figure 2. Increasing "Noise Sensibility" [3]

What about the "basic noise level" in classrooms over 5 lessons in the morning under different acoustic conditions? Fig. 3 shows the increasing Basic Noise Level in classroom with "bad" 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 SPL over all lessons.

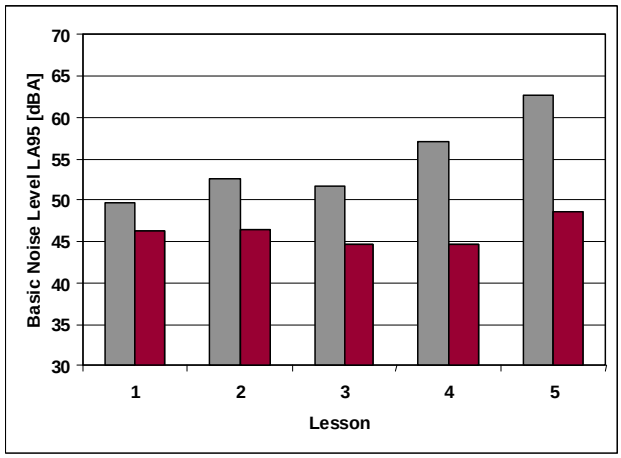

Figure 3. Basic Noise Level over all lessons in the morning, ■ "bad" , ■ "very good" room acoustic

With "bad" acoustics in classroom "working noise" will increase on "Lombard Effect" and becomes more and more a stressor with increasing fatigue. With "very good" acoustics breaks between lessons are long enough for recreation, there is no increasing of SPL.

Analyzing details of the pedagogical process, e.g. different types of teaching, will show reaction of students on acoustic conditions, Fig. 4. Generally two types are differentiated, "direct teaching" (dT), teacher in front of the class talking to all

students, and "student centered teaching" (scT), students are working in groups. Changing type of teaching from "dT" to "scT" under "bad" acoustic will increase SPL, under "very good" acoustic opposite.

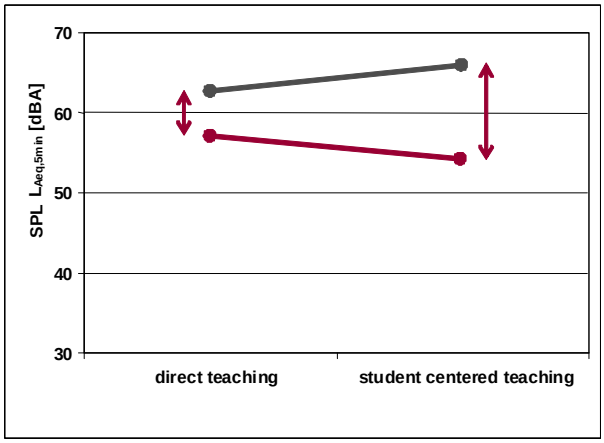

Figure 4. "Working Noise Level" for different types of teaching, ● "bad" , ● "very good" room acoustic

There are two reasons for this effect of reducing "Working Noise Level" during many students are working and talking together:

1. "very good" acoustic gives high absorption of noise with high "speech intelligibility", so no one has to talk loud with his neighbor
2. lower SPL reduces stress and fatigue and gives higher concentration, much better working conditions
3.

One indicator for better working conditions is power of concentration on pedagogical process by students. It's difficult to measure concentration continuously, but it's easier to count "dysfunctional activities" like heckling or crying by students. Fig. 5 shows difference for dysfunctional activities in identical pedagogic situations, same students, same teacher, under "bad" and "very good" acoustic conditions.

Increasing SPL over the morning creates stress with following fatigue, loss of concentration and increasing "dysfunctional activities". In opposite "very good" acoustic working conditions reduces stress and give high concentration over all lessons.

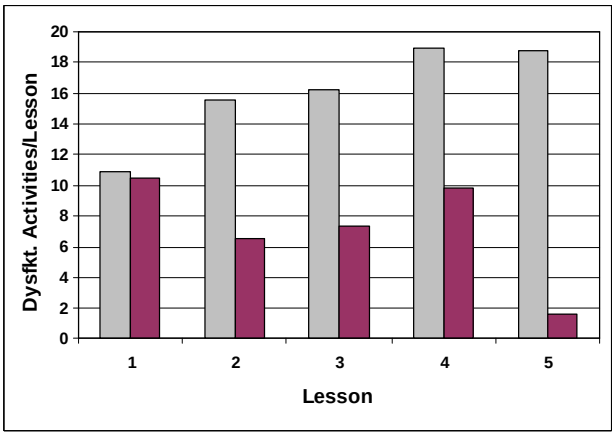

Figure 5. "dysfunctional activities" during the morning, ■ "bad" , ■ "very good" room acoustic

A second indicator for change in pedagogic process is summary of different types of talk, e.g. "teacher generated speech" (TgS), "student generated speech" (SgS) and "intensive dialog between teacher and students" (DIA). These parameters were monitored by lesson observation. Fig. 6 shows the summary for one week under different acoustic conditions. After refurbishing the classroom acoustics there was only one parameter different to the week before, quotation of "dialog" increased. This is typical for more intensive teaching process. That's opinion of the involved teachers.

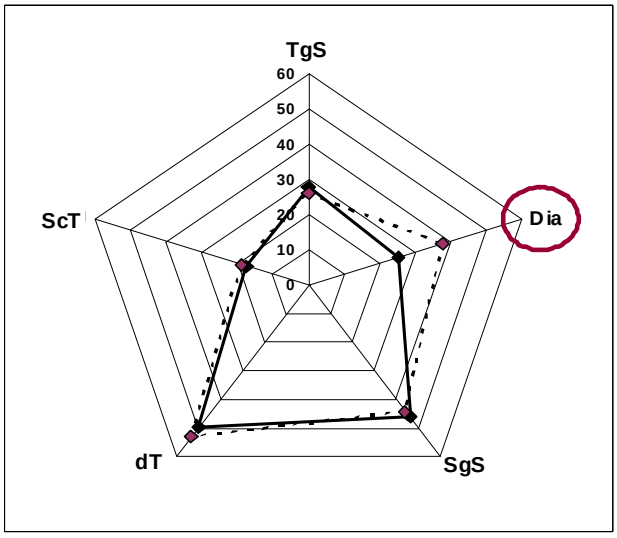

Figure 6. Teaching Grid, ▬ "bad" … "very good" room acoustics

The importance of room acoustic for working conditions is shown by data from research done by the ISF on effects of air quality in classroom on teaching process and students behavior. Indicator for air quality and another reason for fatigue is the

quotation of CO_2, the lower the better. Lowering the quotation of CO_2 was done by ventilation in the mid of the lesson for 2 minutes. This was enough to eliminate fatigue. Measured SPL during lessons shows nearly the same effect as in Fig. 2, influence of air quality is comparable with stressor noise. The importance of room acoustics is shown in Fig. 6.

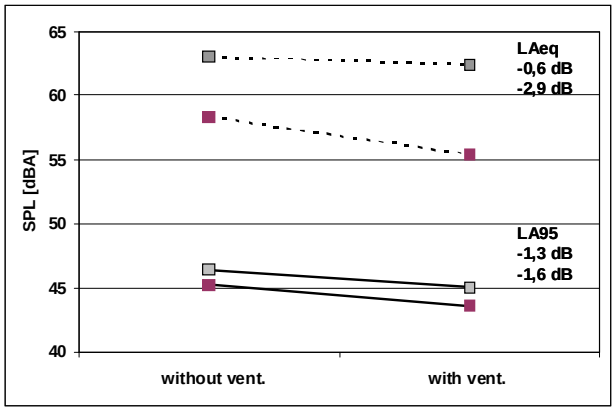

Figure 6. Lowering of SPL in classroom by ventilation, ■ "bad" , ■ "good" room acoustic

Reducing stressor CO_2 by ventilation gives better working conditions, reduces fatigue and raise concentration. But the effect under "good" room acoustics is much better than in classrooms with "bad" acoustics.

3. Conclusions

All shown reactions on different acoustic conditions in classroom can be interpreted as interaction between stress situation and behavior. so, what happens?

improved room acoustics
▼
improved communication
▼
reduced working SPL
▼
reduced speech effort
▼
lower stress
▼
change of behavior

This process runs continuously during pedagogic process all over the day.
Good acoustics is a measurable ergonomic factor and contributes to better human working conditions in school environments!

References

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