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Louder than a rock concert? – Noise in sport halls as an ergonomic working condition for teachers and students

Gerhart Tiesler
ISF Institute of Interdisciplinary School Research, Bremen, Germany.

Simone Lang
ISW Inst. of Sport Science, University of Rostock, Germany.

Summary
Description of teaching reality in sport halls is the main topic of this research project about "noise at schools". During the time period 2000 to 2006 three studies were per-formed from an interdisciplinary workgroup by the University of Bremen, Germany. Altogether 5 individual schools were investigated for at least nearly 600 lessons. The data collection was according to established methods of occupational science such as acoustical measurements. These included sport halls as well as classrooms and the data were recorded for the full morning. The recorded data are available as time series; therefore the recordings allow separating between individual teaching stages. Consequently, it is possible do draw conclusions concerning the acoustic stress of the teaching staff caused by the noise. It is possible as well to describe differences between pedagogical and acoustical improvements und its effects on the noise level. The results will be discussed according to official regulations. Within the three studies additional to the recordings the influence of pedagogical treatments concerning the noise level as well as the effect of noise reducing equipment was investigated. As a result improvements concerning the working conditions as well as the case level surrounding several thousand teachers and students can be developed.

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1. Introduction

The data reported in this article are from the research "Noise at educational institutions" (Schönwälder et.al., 2006)[1]. Most results of analyzing lessons in schools, nearly 600, have been published at Euronoise 2006[2]. The main topic of research was to describe the workplace at school with the rules of occupational science to "humanize the world of work for students and teachers". More than 80% of the teachers say "noise made by students is a strain". Noise in schools, especially in class rooms is a sum of working noise, communication, sound of breathing and moving people. Last but not least noise is a result of room characteristics like acoustic. No teacher has the idea to teach his students in a tunnel or hall of railway station or beside a motorway. Situations in sports halls sometimes are comparable with tunnels related on acoustics.

1.1. Stressor Noise

Noise is the most important stressor for mankind, it's impossible to close the ears, so noise is every time present, not only SPL > 80 dBA, also silent noise with SPL < 80 dBA. One example from a lesson in classroom is shown in Fig.1.

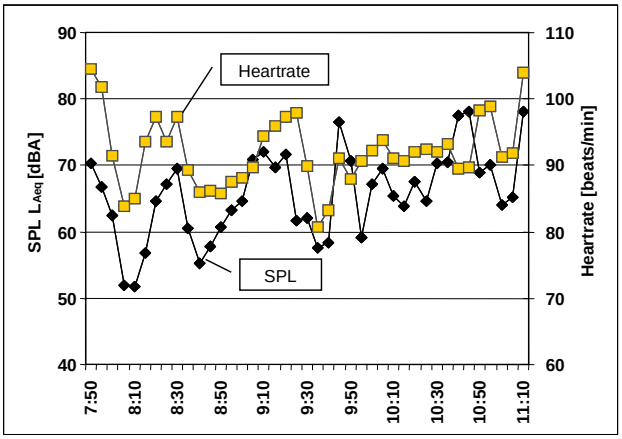

Figure 1. Heart rate of teacher and working SPL in classroom (Mean values of 5min time slices)

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Heart rate of the teacher and SPL of working noise in the classroom was monitored synchronously every 5 sec and mean value of 5 min was calculated and plotted together in Fig. 1. The high correlation between heart rate and working noise level in the classroom is an indicator for high importance of noise as a stressor for human beings.

1.2. Noise and speech intelligibility

In normal conversation there must be a speech to noise ratio of more than 9 dB and SPL of human speech is about 45 to 65 dBA. The surrounding noise should not be louder than 54 dBA for normal speech, in other case people have to increase speech pressure, but without increasing speech intelligibility. Teaching students in sports speech is a very important factor in case of safety and health. Conditions for communication in noise surrounding are shown in Fig. 2.

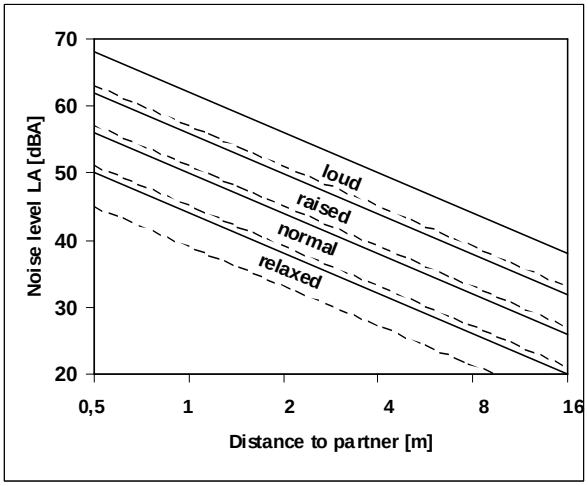

Figure 2: Admitted Noise level for very good (- -) or good (▬) Speech transmission depending on the distance talker to listener and effort of speech (ISO 9921-1)[3]

Using these results it's necessary for teachers in sport halls with mean SPL between 80 and 90 dBA to cry most of the time for bad speech intelligibility. Czehowsky [4] gives data out of gymnasiums with SPL from 81 to 91 dBA and 14 to 28 students. But there is no correlation between number of students and measured SPL and no correlation with kind of sport. The noise situation in sport halls is comparable with the noise situation at a rest area 10 m beside a motorway. To give a signal under these working conditions needs a whistle of nearly 90 dBA. For this case every people has to use ear protectors by regulations of occupational safety. Effects of noise on human beings are shown in Fig. 3. Especially loss of concentration and reduced speech intelligibility are important factors for safety and health during sports.

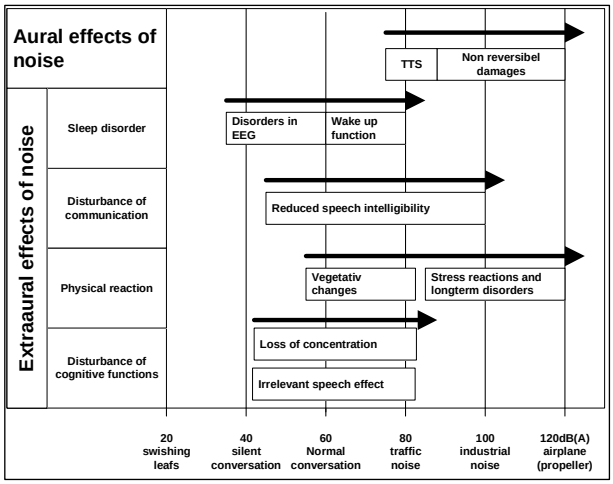

Figure 3. Overview about aural and extra aural effects of noise. According to: Lexikon der Psychologie [5]

1.3. Susceptibility to Noise

Exposure to noise for a school day, for example six lessons at school from beginning to noon, results in increasing of sensibility to every kind of sound. Every teacher in this study had to estimate the working noise level for each lesson with a scale from 1(extremely silent) to 7(dolorous). The quotient of estimation and mean SPL gives the "sensibility to noise" in equation (1).

$$Sensibility = \frac{Estimation}{SPL} \qquad (1)$$

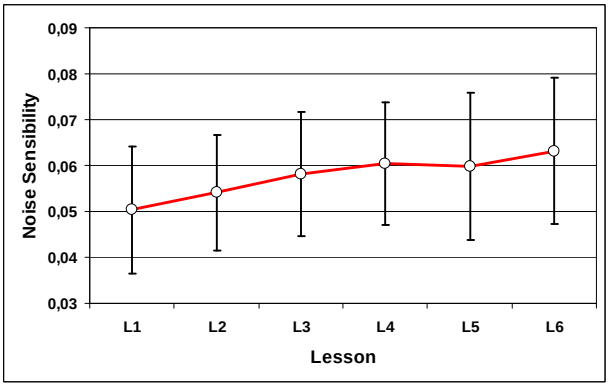

Figure 4: Change of noise sensibility over 6 lessons.

This means, that an identically SPL will be estimate higher in the 6th lesson then in the 1st lesson as an effect of strain by noise.

2. Noise level in schools

Question Nr. 105 in questionnaire about workload of teachers by Schönwälder et.al.[6] was: „concerning the students I'm primarily stressed by … noise, made by students." More than 80% of interviewed teachers answered "applies sometimes or fully". Based on this result the 'Federal Institute

for Occupational Safety and Health' financed research on 'Noise in educational premises'[1].

2.1. Noise in classrooms

One of the results in that research is the correlation between reverberation time (RT) an basic noise level (LA95) in classrooms, shown in Fig. 5. The result: the better room acoustic the more silent working situation [7].

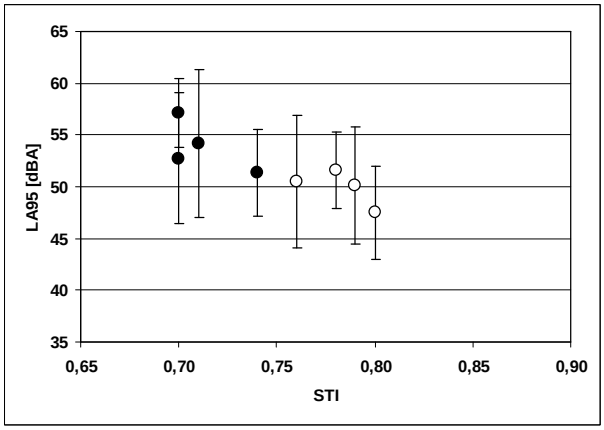

Figure 5: Basic SPL LA95 depending on STI of the class rooms of Grundschule Stichnathstraße; total classes; 1st (○) and 2nd floor (●)

One reason for increasing of SPL during work is the Lombard effect; everyone has to speak louder than his neighbor for better speech intelligibility. So working condition became louder and louder. Additionally increasing SPL gives more strain to all people in the classroom, less concentration and attention. Schönwälder et.al.[1] show how noise level in schools changes over school days up to +11dB, based on fatigue by strain of noise.
Reducing fatigue by improvement of working conditions (renovation of classroom acoustics) is shown in Fig. 6 by Oberdörster&Tiesler [7].

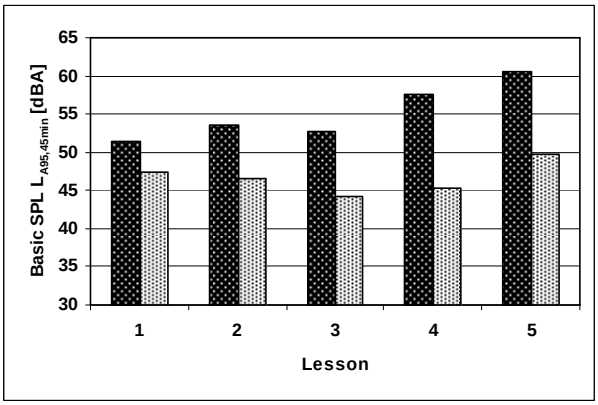

Figure 6: Mean Basic SPL $L_{A95,45min}$ before (▒) and after (▒) acoustical renovation

Before renovation of room acoustic (RT=0.75sec) the basic noise level raised from 1st to 5th lesson about 10 dB and afterwards (RT=0.4sec) there is no change. The reason therefore is the more silent working situation, no speech effort and much better speech intelligibility.

2.2. Noise in sport halls

Most of gymnasiums have bad room acoustics with very good hall effects. There is more noise energy produced than absorbed. Fig. 7 shows typical sequence of 5 sport lessons, 45 min each, at an elementary school, students from 6 to 12 years old.

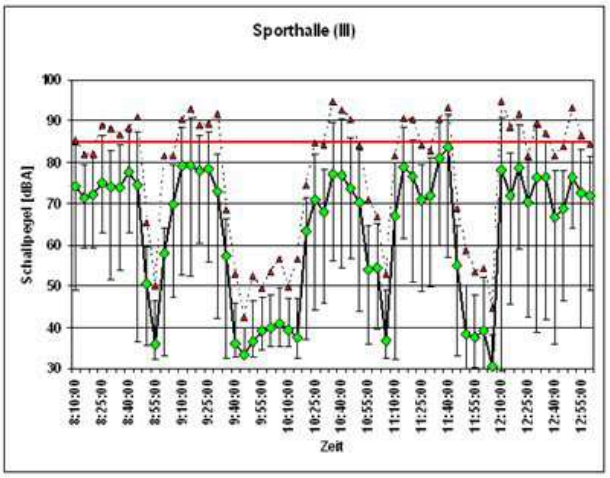

Figure 7. Sound pressure level during sports.
♦ LA_{eq5min}, ▲ LA_{max}

Three typical examples of sport lessons of 90 min are shown in Fig, 8. The peak values $L_{Aeq,1sec}$ for each lesson is added. One problem of regulations on noise protection is the calculation of workload by noise. Summarized SPL over 8 hours for teachers in sport halls is much less than safety value of 80 dBA, founded on only 30 to 35 min phases with very high SPL and all other time with much lower SPL.

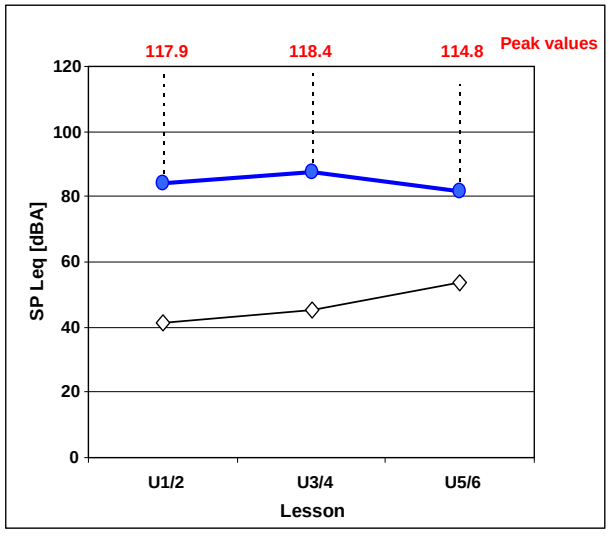

Figure 8: Mean SPL for 90min lessons in sport halls.
● sport with students, ◊ empty sport hall

But phases of high sporting activity are very loud and especially critical for communication and safety. Regulations on noise protection calculate only probability of noise-related hearing impairment, but no extra aural effects. Increasing of SPL in the empty sport hall is induced by increasing of noise level in surrounding areas, e.g. school building.
There is only one option for reducing working noise level and increasing conditions for communication and safety: change for better room acoustic and speech intelligibility.

2.3. Workload reaction on noise by humans

As shown in Fig. 3 there is also a physiological reaction on noise, a stress reaction. There is a change of vegetative processes in human, i.e. increasing activity of the cardio vascular system preparing fight or flight. The Strength of reaction depends on different personal and situational parameters. Indirect measurement of stress assimilation was done by using the parameter "sensibility on noise", shown in Fig. 4.
Occupational medicine uses measurement of heart rate as an indicator for workload. The Reaction of cardio vascular function is very sensible on change of workload but also indifferent. There is no difference i.e. between physical or mental stress. To get an idea of workload by noise we used data from a teacher in a normal classroom with identical teaching situations but different room acoustics [7].

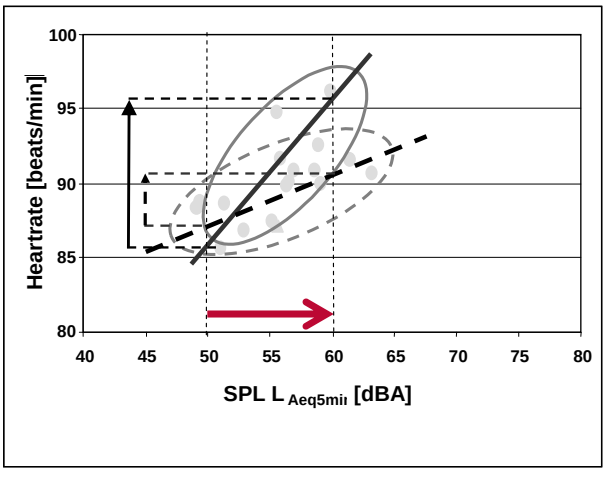

Figure 9: Heart rate reaction on noise before (—) and after (- - -) acoustic refurbishment of classroom

SPL in classroom and synchronously the heart rate of the teacher was monitored during all lessons of two weeks, one week with bad (RT=0.75sec) and one with good (RT=0.4sec) room acoustics. Mean values for every 5 min slices were calculated and plotted in Fig. 9. Under bad acoustics the heart rate increased nearly 10 beats/min depending on the increasing of SPL by 10 dB, under good conditions only 4 beats/min. These are only 40% of the former stress reaction. We presume that teachers in sport halls must have similar reactions, but there is no comparable research.

3. Conclusions

There is only one possibility to reduce working noise level and giving better working conditions to teachers and students in sports halls by reducing RT corresponding to standards, e.g. in Germany DIN 18032[8] and respectively DIN 18041[9]. Reducing noise level results in better communication, much more safety and health and less stress.

Acknowledgement

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More information:
www.ISF-bremen.de
www.schulakustik.de

References

[1] H.-G. Schönwälder et.al.: Lärm in Bildungsstätten (Noise in Educational Premises), Schriftenreihe der BAuA, Dortmund, Fb 1030, 2004.

[2] G. Tiesler, M. Oberdörster: Noise a stress factor. Proceedings Euronoise, 2006.

[3] ISO 9921-1: Ergonomie – Beurteilung der Sprachkommunikation. Beuth Verlag, Berlin, 2003.

[4] .P. Czehowsky: Lärm im Sportunterricht. DSLV-Info, 3, p 10-12, 2005.

[5] Lexikon der Psychologie in 5 Bd., Spektrum Akad. Verlag, Heidelberg, Berlin, 2001.

[6] H.-G. Schönwälder et.al.: Belastung und Beanspruchung von Lehrerinnen und Lehrern. Schriftenreihe der BAuA, Dortmund, Fb 989, 2003

[7] M.Oberdörster & G.Tiesler: Acoustic Ergonomics of School. Schriftenreihe der BAuA, Dortmund, Fb 1071, 2006.

[8] DIN 18032: Hallen und Räume für Mehrfachnutzung. Beuth Verlag, Berlin, 2003.

[9] DIN 18041: Hörsamkeit in kleinen bis mittelgrossen Räumen. Beuth Verlag, Berlin, 2004.