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NOISE - A STRESS FACTOR? ACOUSTIC ERGONOMICS OF SCHOOLS

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ABSTRACT

This investigation into the effects on teachers of the natural work "noise" occurring in lessons is based on an analysis of the altered pedagogical approach in everyday school life (cf. Oberdörster: Acoustic Ergonomics of School). Is it correct to speak in general of "noise stress" or is this stress more an emotional reaction to the kind of work in which teachers are engaged? Based on recordings taken in 175 lessons this article describes how room acoustic conditions influence the teachers' measurable physiological load in relation to classroom events, teaching method and shares of speech. The data as a whole can be resolved into 5-minute time slices for the purposes of the analysis. We analysed different conditions in one primary school on the basis of four classes in rooms with a reverberation time RT>0.5 s and four classes in rooms with a reverberation time RT<0.5 s. At a second primary school we analysed the effects of the room acoustic refurbishment (reverberation time improved from 0.7 s to 0.4 s). Our database comprised continuously recorded sound intensity levels $L_{A,1sec}$, lesson observations by two observers (recording teaching events per second) and continuous recordings of the teacher's heart rate. Hence it is possible for the first time to consider classroom events and their effects on the teachers as a process.

1 INTRODUCTION

Can the school be considered as a workplace which is or can be designed in accordance with the familiar ergonomic principles of occupational science? We are not looking at a production operation here, at least not in the traditional sense of occupational science. Nevertheless, people are engaged in a task and spend a large part of their working day in this environment. This workplace is comparable in this sense with that of a service provider. In terms of "humanising the world of work" it is legitimate to consider schools from this viewpoint and analyse them more closely.

Amongst many other activities, teaching is at the heart of the work carried out in schools and both pupils and teachers are obliged to react in their own ways to this basic task. However, using the tools of occupational science what is that we need to describe or analyse? What is the work or rather the production process? The answer is simple: teaching and (as demonstrated by Oberdörster/Tiesler[2]) any reliable judgements about teaching require a multi-dimensional observation of the "reality of teaching". In this case we look at the stress of those involved in this working situation. What effect does the teaching workload have, e.g. on teachers? The stresses and extent of stress within the teaching profession have been extensively demonstrated by Schönwälder et al.[3].

Within occupational physiology the heart rate of workers is used as a particularly good indicator of stress[1]. While the absolute value of this indicator is individually very variable, intra-individual reactions are very load-specific. They are also very fast and reliable. However, the change in itself is very non-specific as regards stimulus. To differentiate e.g. between anger and pleasure as a trigger of change requires a real-time "observation" of the situation. This allows us to draw reliable conclusions about the intensity of the load for the observed person – and thereby answer a basic question relating to stress analysis.

2 NOISE IN TEACHING

The majority of the teaching staff (80% of 1200 teachers)[3] have cited the phenomenon of "noise in school" as a stress-inducing factor as shown in earlier investigations. As well the relationships shown by Oberdörster/Tiesler[2], school organisation plays a major role in this. One year 1 class in one of the primary schools that took part was taught in 90 min. units, something like 6x the maximum concentration span at this age. The building was built in the year 1895 and the average reverberation time in the classroom was RT=0.9 s. The considerable rise of the working SPL shown in Fig. 1 for three teaching days in a week indicates increasing unrest, possibly due to fatigue, in each of these over-long units.

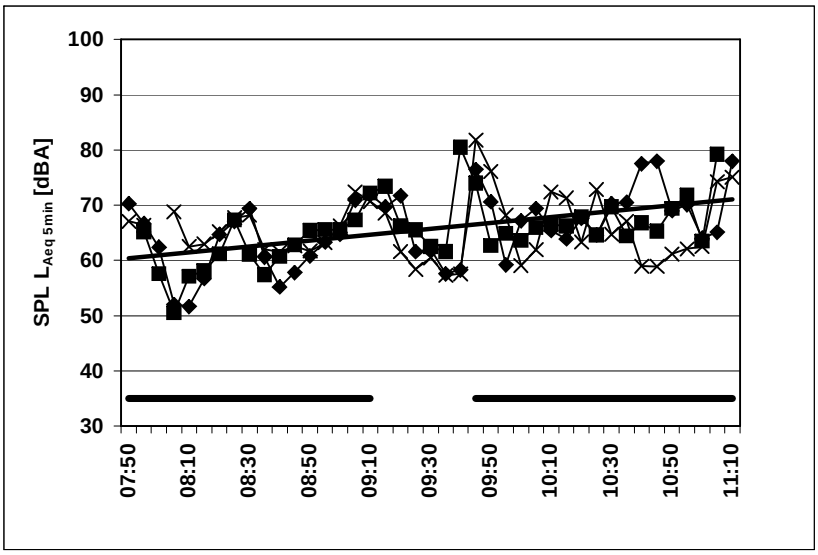

Fig. 1. Working SPL $L_{Aeq,5min}$. over two double lessons (1st+2nd and 3rd+4th lessons), three teaching days, regression line for Monday (+11dB over 4 lessons)

3 STRESS

The rising noise level in such a situation is not without consequences for the teacher's stress. The course of the continuously recorded heart rate as an indicator of psycho-physiological stress provides the evidence.

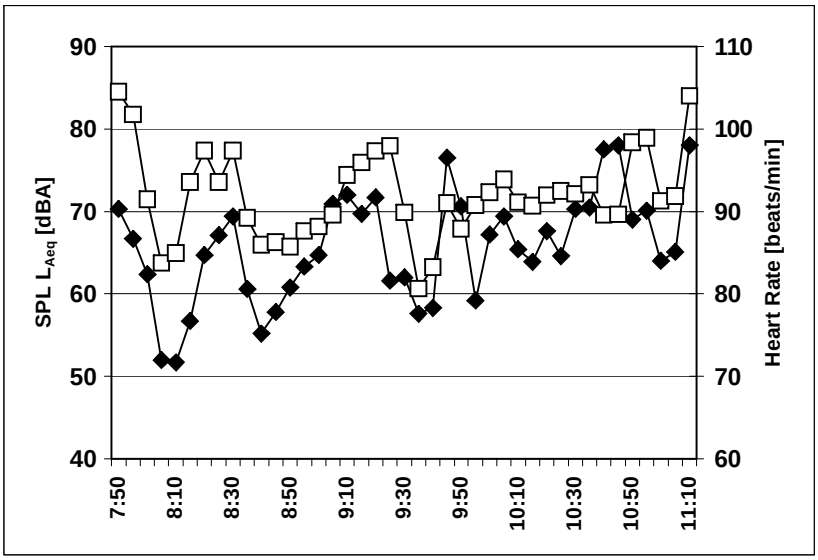

Fig. 2. Comparison of the SPL trend (♦) and stress response (heart rate) ( ) of the teacher over two double periods (Mo11/German and Mo12/General Knowledge)

Fig. 2 shows the relationship between the SPL in a classroom and stress during one day of the investigation. The synchronous trend of the two parameters is clearly visible. The dependence of stress (HR) on the load (SPL), shown in Fig. 3, indicates a surprisingly high regression coefficient of r=0.55. If one considers that noise is only one of many other load values, this is a significant relationship.

Although the sound intensity level in the classroom is a long way away from the values normally significant for occupational safety (80 and/or 85 dB(A)), these relationships provide clear indications of the significance of noise of average intensity as a stress-inducing factor in a more cognitively orientated context.

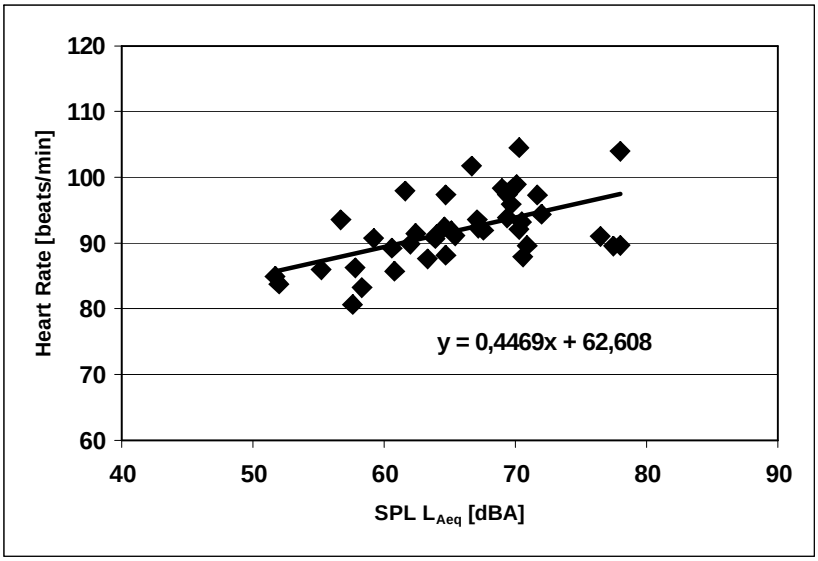

Fig. 3. The same data as in Fig.2 (Mo1), in this case however showing the relationship between HR and SPL.

Data from other schools participating in a project carried out on behalf of the Bundesanstalt für Arbeitsschutz und Arbeitsmedizin (German Federal Institute of Occupational Safety and Health)[4] confirm the general validity of this individual finding:

4 EFFECT OF NOISE

Of particular significance in this context is the data from "Primary School V"[4] in which the room acoustics of one classroom were changed while all other conditions remained constant (see also [2]). The reduction of the average reverberation time from RT=0.7 s before the refurbishment to RT=0.4 s afterwards led not only to a clear drop in the basic- and working SPL of up to 10 dB (cf. Oberdörster: Acoustic Ergonomics of School), but also had demonstrable effects on the stress of the teacher, once again measured via the heart rate (HR) as the most sensitive indicator for stress reactions.

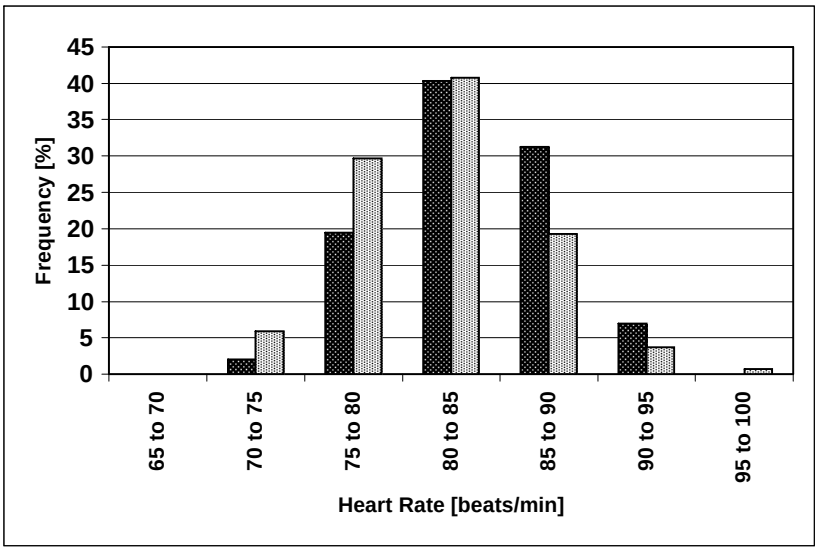

Fig. 4. Distribution of basic activation in teaching, grouped according to the conditions before (▓) and after (▒) refurbishment; Baumberge Schule; data from all lessons from both weeks

The distribution of basic activation in Fig. 4 shows the shift of the HR from the range 80-90 beats/min to 75-85 beats/min under the better acoustic conditions in the room.

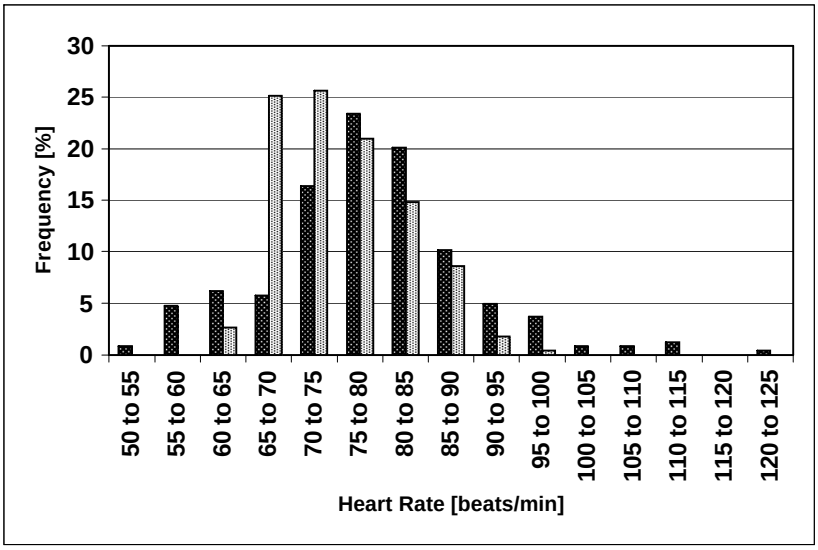

Fig. 5. Distribution of the basic activation in teaching for all teachers, grouped according to classrooms, RT<0.5s (▒) and RT>0.5s(▓); Grundschule Stichnathstr.

The relationship is also confirmed by the data from "Primary School III"[4]. The teaching was analysed throughout a total of 175 lessons in 8 classes. The classrooms were located on 2 storeys and had slightly different reverberation times. Although the difference in the room

acoustics between the two storeys was far less (ground floor: 0.6 s; top floor: 0.45-0.5 s) than in "Primary School V", once again the ergonomic effect is very obvious. (Fig. 5).

5 CONCLUSIONS

The present results verify the ergonomic dimension of room acoustics in schools: Acoustically optimal classrooms with reverberation times of less than 0.5 s lead to significantly less working stress amongst the teachers.

The further analysis of the shares of activation and fatigue also shows a reduction of fatigue under the more favourable acoustic conditions.

The analysis of stress in the individual case (in this case one teacher at "Primary School V"), e.g. with respect to the teaching method, shows the reduction in stress particularly clearly when that teacher is speaking. The working pulse of the teacher during direct teaching phases is below 90 beats/min for 60% of the time before the refurbishment but for 82.5% of the time after the refurbishment. In the final outcome this means that the teacher taught with up to 10 beats/min reduced average heart rate in the 5 to 10 dB quieter lesson – clearly more relaxed.

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