Low frequency noise and annoyance in classroom

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The most common method for noise assessment is the A-weighted sound pressure level. The question has been raised as to whether the frequency weighting with an A-filter gives a correct result when assessing the annoyance response to noise containing strong low frequency noise (LFN) components. One method suggested to identify LFN is the dB(C) – dB(A) difference. The aims of this study are to investigate if background noise in Swedish elementary schools is to be considered as LFN, further to test the hypothesis that students exposed to audible LFN at high levels are more annoyed than students exposed to LFN at lower levels. The results indicate that the noise in 16 out of 22 classrooms should be considered as LFN. The analysis did not show any difference in rated annoyance between students exposed to high LFN levels and students exposed to low LFN levels.

1. Introduction

In 1997 The National Board of Occupational Safety and Health in Sweden carried out a survey on the working environment in Swedish elementary schools (7–15 years) (Swedish National Board of Occupational Safety and Health 1997). Headteachers in Sweden were asked about the working environment at their school. Findings in this survey were that the most common environmental problems at school were related to indoor climate and "noise, sound and acoustic problems". The daily activities in the classroom are based on communication and concentration. The working methods in schools in Sweden today differ a lot from the traditional method of lecturing. The teaching methods are nowadays more focused on problem solving. The students are more interactive, eg. discussing with each other and working in groups and projects. The teacher has more and more become a supervisor, guiding not lecturing. The acoustic conditions in these environments are very complex for the constitution of the framework for classroom organisation, management and the learning process. Noise exposure problems vary in different school environments due to the presence of different noise sources, speech and other noises related to student activity. However, the risk for hearing damaging noise exposure during classroom activities is low. On the other hand there is a compelling body of research showing adverse effects of noise on speech communication, performance, short time memory and learning (e.g. Pekkarinen & Viljainen 1991, Jones et al. 1990, Enmarker et al. 1998).

A great number of external noise sources such as ventilation systems, activities in the school building, air and road traffic noise interfere with the school work. Road traffic noise may reduce attention (Enmarker et al. 1998). Bronzaft and McCarthy (1975) compares reading ability and sound pressure levels for schools close to railroads. Students in classrooms with the highest sound levels were found to be late in their development of reading. Moreover, Cohen et al. (1980) have reported that air traffic noise can affect reading comprehension and mathematical proficiency. Inside the classroom noise sources such as projectors and other technical equipment are present. However, at school as in many other working environments such as offices, shops, service and hospitals, the main part of the noise originates from human activity.

An effect of noise that has to be considered in the school environment is annoyance. Holmberg (1997) points out that in occupational environments noise annoyance as well as negative effects on performance will increase with increasing sound level, tonal character and variability of the noise. Differences in responses seem to exist between high and low frequency noise exposures. Despite the complexity of noise annoyance, the most common method for noise assessment is still the A-weighted sound pressure level. The

question has been raised as to whether the frequency weighting with an A-filter gives a correct result when assessing the annoyance response of noise containing strong low frequency noise (LFN) components. The interval between the hearing threshold and an unacceptable level is much smaller for LFN than for noise with higher frequencies (ISO 1985). At low frequencies annoyance may appear just above the hearing threshold level. Persson Waye (1995) presents results indicating that annoyance experienced from low frequency noise is higher than annoyance from noise without dominant LFN components at the same level. There are also several observations that point out that the A-weighting underestimates the annoyance from LFN (Kjellberg et al. 1984, Persson & Björkman 1988, Leventhall 1980). The definition of LFN varies and there is no internationally agreed definition. Castelo Branco & Rodriguez (1999) suggests frequencies up to 500 Hz and Berglund et al. (1996) suggests that frequencies up to 250 Hz should be considered as LFN. Dealing with annoyance, an appropriate definition of LFN could be "noise with a dominant frequency content of 20 to 200 Hz" (Persson Waye 1995). One method that has been used in some Swedish recommendations to identify LFN is the dB(C) – dB(A) difference (Swedish National Board of Health and Welfare 1996, Swedish Royal Board of Building 1992). This will constitute an estimate of how much energy is to be found in the low frequency part. A limit of 15–20 dB is also given over which the noise is to be considered as LFN (Swedish National Board of Health and Welfare 1996). Persson Waye (199) suggests that this method should only be used when the level is above 30 dB(A). One aim of this study is to investigate if background noise in Swedish elementary schools is to be considered as LFN. Further to test the hypothesis that students exposed to audible LFN at high levels are more annoyed than students exposed to LFN at lower levels.

2. Method

Sound levels were recorded in 22 unoccupied classrooms at three typical schools in Sweden under similar conditions with normal activity in the surroundings. The noise was recorded using a sound level meter (Brüel & Kjaer 2237) with a 1/2" microphone (B&K 4189) and a digital tape recorder (TEAK DA-P20). The sound level meter was placed in a representative, asymmetrically situated position in the classroom corresponding to the ear height of the students in order to measure the perceived noise. The measurements were made for 10 minutes.

The recordings were analysed according to A- and C- weighted levels. The $L_{Ceq} - L_{Aeq}$ difference was calculated from the equivalent sound levels. The classrooms with a $L_{Ceq} - L_{Aeq} < 15$ dB were categorised as low LFN level exposure and classrooms with $L_{Ceq} - L_{Aeq} > 20$ dB were categorised as high LFN exposure. In a further part of the study A- and C-weighted levels were calculated for a limited frequency range, i.e. 63–20kHz. This was made to obtain a $L_{Ceq} - L_{Aeq}$ level difference based on the frequency range in which the sound pressure level exceeded the hearing threshold level. The result is a $L_{Ceq} - L_{Aeq}$ difference based on the frequency range with levels above the hearing threshold level for frequencies in the lower part of the spectra, $L_{Ceq(63–20kHz)} - L_{Aeq(63–20kHz)}$. The classrooms with a $L_{Ceq(63–20kHz)} - L_{Aeq(63–20KhZ)} < 10$ dB were categorised as low LFN level exposure and classrooms with $L_{Ceq(63–20kHz)} - L_{Aeq(63–20kHz)} > 13$ dB were categorised as high LFN exposure. The 337 students working in these 22

Bar staff

Following criticism from MEP's of the proposal in the draft EU physical agents directive on noise hazards that earmuffs should be worn by disco bar staff, the European Parliament has decided to seek further changes to the draft EU physical agents directive. In the Strasbourg vote on the directive, which cleared its second reading on 13th March 2002, MEPs approved the most recent version of the European Commission's draft, which now incorporates some of the amendments sought by the Parliament at earlier stages. But they also agreed to pursue further amendments which have been resisted by national governments. Unless the Council of Ministers backs down, the final shape of the Directive will have to be settled in "conciliation" negotiations between the Parliament and the Council - procedures which could delay enactment by 6 months. Although Strasbourg agrees that the upper action value can be set at 85dB(A), MEPs want to improve protection from the effects of "very powerful impulses" in the form of short-term peaks of sound pressure. Other amendments seek to reinforce requirements on the training of workers in correct use of protectors, and would make employers responsible for enforcing their use.

classrooms were asked to report their annoyance in a multiple-choice questionnaire. Five alternatives were given. “Not at all annoyed”, “Somewhat annoyed”, “Quite annoyed”, “Much annoyed” and “Very much annoyed”.

To test the hypothesis that students working in classrooms with high LFN levels are reported to be more annoyed than students working in classrooms with low LFN levels, a Mann-Whitney U-test was used. The same statistical tool was used to show that there was no difference between the groups in L_{Aeq}. The level of significance was chosen to be $p< 0.05$.

3. Results

Table 1 shows that eight classrooms have a $L_{Ceq} - L_{Aeq}$ difference of 15 dB or below. These classrooms are categorised as having low LFN exposure. Nine classrooms have a $L_{Ceq} - L_{Aeq}$ difference of 20 dB or above. These classrooms are categorised as having high LFN exposure. The statistical analysis shows that there is no difference in L_{Aeq} between the groups with low LFN exposure and high LFN exposure ($Z= –.93$ $p> .05$).

Figure 1 displays the distribution of how students reported their annoyance during the lesson. The comparison of reported annoyance between the high- and low LFN-exposed groups, based on an LCeq – LAeq difference to identify LFN, shows that there is no difference in rated annoyance between these groups ($Z= –.84$ $p> .05$). The arithmetical means of the LAeq levels for the LFN exposure groups is 39 dB(A) for the low LFN exposure and 38 dB(A) for the high LFN exposure.

The median, max and min of sound pressure levels in 1/3-octave bands for the 22 classrooms are shown in figure 2. The spectra is related to the normal hearing threshold (ISO 1985). The analysis shows that for the frequencies 25, 31, 40 and 50 Hz all levels are close or below the hearing threshold level.

Table 1. L_{Aeq}, L_{Ceq}, $L_{Ceq} – L_{Aeq}$ difference for unoccupied classrooms

Class room	L_{Ceq}	L_{Aeq}	$L_{Ceq} – L_{Aeq}$
9	52	43	10
15	50	40	10
1	48	37	11
6	53	40	12
11	50	38	12
10	54	40	14
5	52	37	15
2	51	36	15
19	52	35	17
18	53	35	18
22	56	37	18
20	53	34	19
21	55	36	19
3	58	39	20
17	60	40	20
13	54	34	20
16	60	40	21
14	60	39	21
8	60	39	21
7	56	34	22
4	61	38	23
12	58	35	23

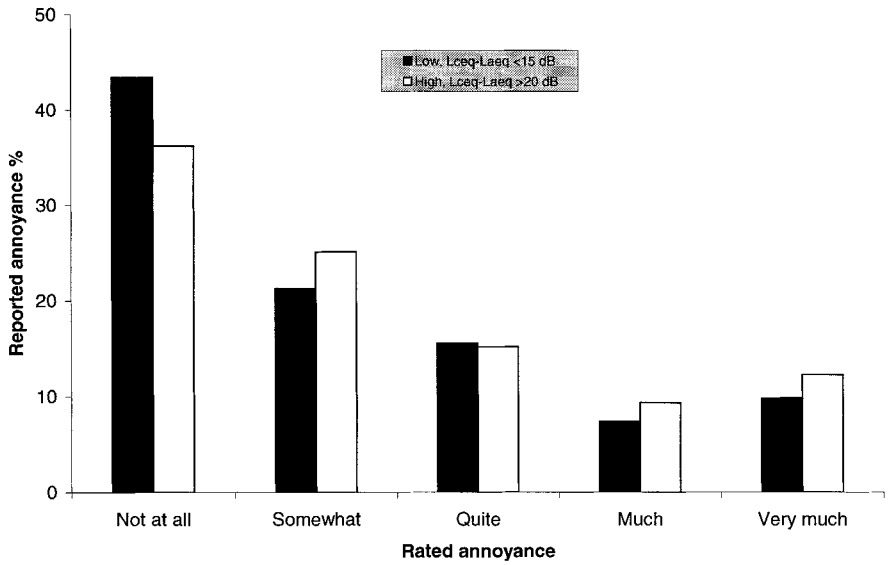

Figure 1. The distribution of reported annoyance between the high- and low LFN-exposed groups based on a $L_{Ceq} - L_{Aeq}$ difference to identify LFN

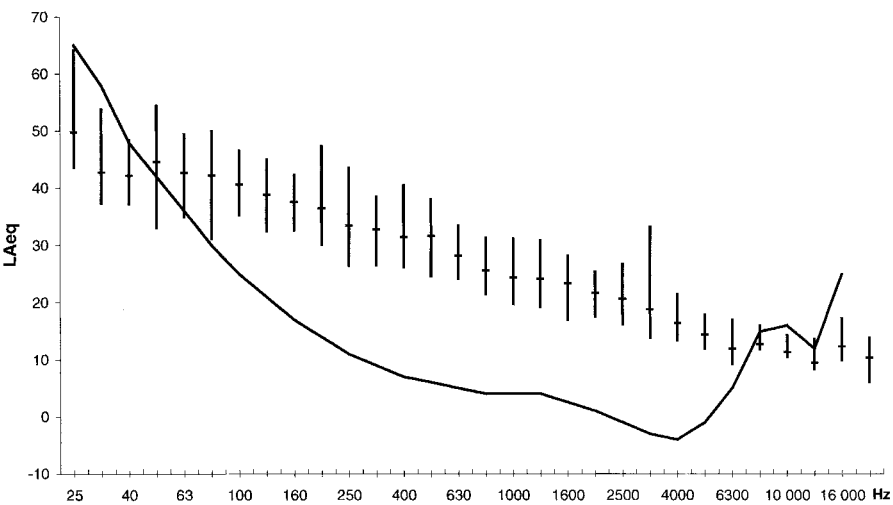

Figure 2. Median, maximum and minimum sound pressure level of 1/3 octave bands for the background noise in the 22 classrooms. The full line shows the normal hearing threshold (ISO 226-1 1985)

Table 2 shows the $L_{Ceq} - L_{Aeq}$ difference based on the frequency range in which the sound pressure level exceeded the hearing threshold level (Figure 2), $L_{Ceq(63–20kHz)} - L_{Aeq(63–20kHz)}$. Nine classrooms, which had an $L_{Ceq(63–20kHz)} - L_{Aeq(63–20kHz)}$ difference of 10 dB or below are categorised as LFN exposures. Ten classrooms, which had an $L_{Ceq(63–20kHz)} - L_{Aeq(63–20kHz)}$ difference of 13 dB or above are categorised as high LFN exposures.

Figure 3 displays the distribution of how the students reported their annoyance during the lesson. The comparison of the reported annoyance between the high- and low LFN-exposed students, based on a $L_{Ceq(63–20kHz)} - L_{Aeq(63–20kHz)}$ difference to identify LFN, shows that there is no difference in rated annoyance between the groups (Z= –.57, p> .05). The arithmetical means of the $L_{Aeq(63–20kHz)}$ for the LFN exposure groups is 39 dB(A) for the low LFN exposure and 37 dB(A) for the high LFN exposure.

4. Discussion

This field study shows that the noise in 16 of the 22 classrooms investigated is to be considered as LFN using the method cited by the Swedish National Board of Health and Welfare (1996). Further the statistical analysis did not show that students exposed to high LFN levels reported more annoyance than students exposed to low LFN levels when using the $L_{Ceq} - L_{Aeq}$ difference to identify LFN. In the further part of the study, A- and C-weighted levels were calculated for a limited frequency range, 63–20kHz.

Table 2. $L_{Aeq(63–20kHz)}$, $L_{Ce(63–20kHz)}$, $L_{Ce(63–20kHz)} – L_{Aeq(63–20kHz)}$ difference for unoccupied classrooms.

$C_{lass\ room}$	$L_{Ceq(63–20kHz)}$	$L_{Aeq(63–20kHz)}$	$L_{Ceq(63–20kHz)} – L_{Aeq(63–20kHz)}$
1	44	37	7
17	47	40	7
9	50	43	7
15	47	40	8
11	47	40	8
6	49	41	9
19	45	35	10
18	45	36	10
2	46	37	10
5	48	38	11
10	52	40	11
21	48	36	12
8	52	39	13
3	52	39	13
22	51	38	13
12	48	35	13
14	52	39	13
7	48	34	14
4	52	38	14
13	48	34	14
16	54	40	15
20	49	34	15

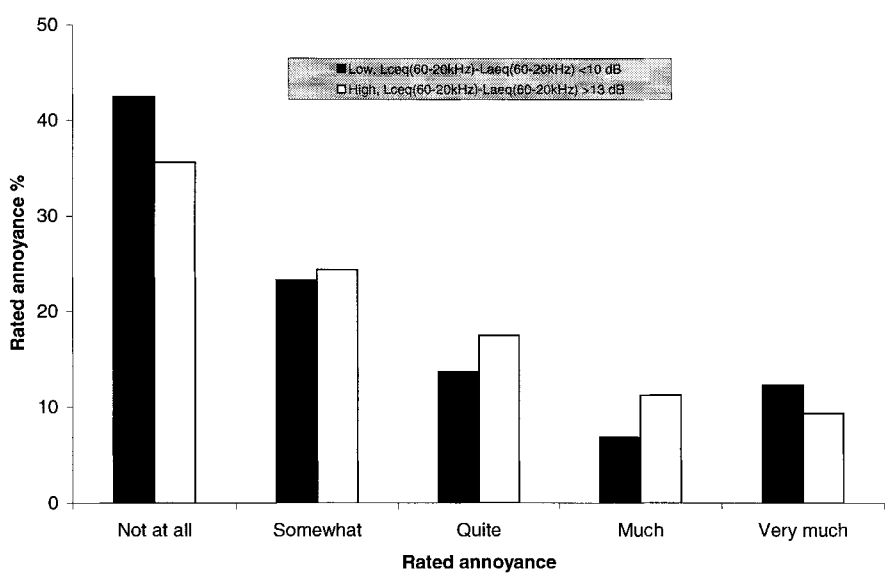

Figure 3. The distribution of reported annoyance between the high- and low LFN-exposed groups based on a $L_{Ceq(63–20kHz)} – L_{Aeq(63–20kHz)}$ difference to identify LFN

The idea is a classification of high/low LFN exposure in a frequency range in which the sound pressure level exceeds the hearing threshold. The theoretical basis is that an annoyance response is based on audible sound. The statistical analysis did not show any difference in reported annoyance between the group exposed to higher LFN exposure and the group exposed to lower LFN levels using the $L_{Ceq(63–20kHz)} – L_{Aeq(63–20kHz)}$ difference to identify LFN. There is no difference in L_{Aeq} exposure between high and low LFN level exposure groups.

On the basis of earlier research there is a problem using this method at low levels. High levels at low frequencies may contribute to a high C-weighted level, yet be below the hearing threshold level. If so, the method to identify LFN may

overestimate energy in the lower part of the spectra. According to this, Persson Waye (1999) suggests that this method should only be used when the level is above 30 dB(A). There are reasons to believe that a recommendation for the use of this method should be even higher than 30 dB(A). The dominant source of the background sound in these classrooms is ventilation. Yet, it is not a correct assumption that ventilation noise is LFN at all times. The National Board of Health and Welfare (1996) also points out the necessity to move on to the use of other methods such as 1/3-octave band analyses to confirm an LFN exposure.

The results in this study do not contradict the proposed method for defining the LFN component, neither that this definition is a relevant method for the risk assessment of LFN annoyance. Earlier research raises the question whether the frequency weighting with an A-filter is a correct method when assessing the annoyance response of noise especially when containing strong low frequency noise (LFN) components. There is a continuous discussion about the complexity of noise annoyance, the concept of noise reactions and interactions with other factors. Maybe this problem is more complex than a matter of measuring methods. The rating is based on the total stimuli, noise load as well as personal and social factors. The school environment is very complex and LFN components are just one of many factors that may influence the annoyance response. The possibility cannot be excluded that the complexity of the school environment obscured the detection of an LFN – annoyance relationship. Noise exposure problems vary in different school environments due to the presence of different noise sources, speech and other noises related to the student activity. These factors have to be considered assessing the effects of noise annoyance in school environments. The problem with noise annoyance must be looked upon as a whole.

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Ministers criticised over silence on noise pollution

Government plans to tackle increasing noise pollution have been condemned by environmental health experts. As complaints about blaring stereos, al fresco bars and roaring traffic reach their summer peak, ministers are accused of failing to introduce the necessary legislation to tackle the problem. Health experts believe that statutory laws are required to ensure that local authorities bother to address noise pollution which was responsible for almost 400,000 complaints last year. Instead, the Government plans to carry out a consultation programme and offer guidelines to councils. Describing the approach as "wholly unacceptable", John Stewart, chairman of the UK Noise Association, said that local authorities must be compelled to act. "There has to be a requirement on them to take noise seriously," he said. "Government guidance is fine, but what we need is fundamental legislation first if we are to get to grips with this problem. There is a huge discrepancy between the different ways authorities deal with noise, and it requires much tighter regulation. Noise pollution is still soaring, and it is doing so unchecked." Mr Stewart said that further "consultation" represented a "full stop" in the Government's interest on noise pollution. "What is coming across is that while the Environment Minister and his department are quite keen on addressing the problem, No 10 does not see it as any sort of priority case. As a result Michael Meacher has reached a bit of a full stop."

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Ordinance enforced – in spades

Police in Baton Rouge have issued more than 400 tickets for noise-ordinance violations since Chief Pat Englade announced in August that officers would make silencing offensively loud noise a priority, a police spokesman said on Friday 2nd November. Police spokesman Don Kelly said that through July 31, police wrote 407 tickets for excessive noise, primarily for people playing car and truck stereos too loudly. Englade sent a memo Aug. 9 to patrol officers asking them to strictly enforce the ordinance. From Aug. 1 through Friday, Kelly said, 421 tickets were issued. That means police wrote more noise tickets in three months than they'd written the previous seven months.

noise notes