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Acoustic intervention at preschools impact on children´s perception and response to high frequency sound qualities

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Abstract

At pre-schools personnel and children are known to be exposed to high sound levels. Tiredness and sound fatigue among the personnel are reported, while less is known about how children are affected. A previously developed interview protocol (INCH) was used to study the effect of an acoustic intervention at seven preschools. Before, 61 children aged 4-6 yrs were interviewed and 59 after. A reduction of the sound level in a range between 1 to 3 dB LpAeq was measured using stationary noise levels meters. The results were analysed using Generalised Estimating Equations accounting for repeated measure of the intervention. The results showed that a change in noise levels in the dining/activity room positively impacted on children's perception of scraping and screeching sounds, frequency of reported tummy ache, and frequency of children reporting the teacher to speak with a raised voice. Perception of scraping sound per se, also impacted on angry reactions to scraping sounds, and children's reporting on teachers speaking with raised voice. Although the intervention affected the noise levels only marginally, it seems to have influenced sound quality aspects related to the higher frequencies in the sound. The results are especially interesting given the new knowledge of children's hearing.

Keywords: preschool, child, sound quality, noise, intervention

1 Introduction

High indoor noise levels from children activities at pre-schools pose a public and occupational health problem [1]. The sounds at pre-schools are loud, highly intermittent and many sounds include high frequency components from screaming voices, activities and in particular surface to surface interaction sounds. Our research have found that children are exposed to significantly higher sound levels as compared to the personnel [2], and new research by Janina Fels [3] further shows that the head related transfer functions of a small child cannot be compared to an adult's and that the ear canal impedance undergo changes up till about 6-7 years of age. Taken together this means that children as compared to adults are exposed to higher sound levels with an amplification in a higher frequency range or around 6000Hz. Moreover, we know from focus group discussions with young child [4] that pre-school children perceive sound different and also respond different from older children and adults at the physiological as well as emotional level [5]. Bodily reactions especially to scraping sounds were in a cross sectional analyses related to more symptoms and less coping.

High frequency sounds from screaming and interaction sounds may hence be perceived as particularly uncomfortable for small children. It seems therefore important to gain more knowledge on this issue, especially when undertaking interventions in settings such as pre-schools and schools.

Acoustic intervention effects in schools and pre-schools have been reported in previous studies and there is some evidence that fitting of absorbents with a reduction of the reverberation time result in better pre-reading skills, improved language skills and a reduced susceptibility to induced helplessness [6] reduced fatigue and heart rate [7] in teachers, and improved phonological processing and social and emotional experience among school children [8]. The sound environment could further be improved by a combination of high performing absorbents in the ceiling and walls, a change in floor carpets, and fitting all chairs with noise reducing cushions. While these factors are well described in text books on room acoustics and their contribution to a better sound environment is highly probable, their effects on human perception and response in adults in general and in children in specific have seldom been investigated. This paper therefore evaluates the effectiveness of an acoustic intervention in terms of noise levels but specifically with regard to its effect on children's perception, bodily sensation, emotional reactions and symptoms. For a detailed description of method and instruments see Persson Waye et al, [5].

1.1 Objective

The aim was to study children's perception and reaction to sounds in their pre-school environment in relation to before and after an acoustic intervention. Specifically, we aimed to study the association of children's perception, reactions and symptoms in relation to the sound environment either as objectively measured or as perceived by the children before and after the interventions.

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2 Method

2.1 Selection and recruitment

In the period between October 2006 to October 2009 children and their parents were recruited from seven preschools where interventions were undertaken with the purpose to improve the acoustical qualities in the preschools in Mölndal, Sweden. In total, 63 children aged 4-5years at the time for the intervention and 59 parents filled out the questionnaire before and after the intervention. The response rates ranged from 80% in the parents to 98% in the children. This paper reports on the data from the children and the acoustic measurement, parental data will be reported elsewhere. Of the children, two fell outside the age range of 4-5 years and were excluded from further analysis, resulting in a study population of 61 children, and full data of 59 children in both the before and after condition.

2.2 Acoustic interventions

Acoustic interventions included changes of floor mats, felt cushions under chairs and sound absorbing tiles on ceilings and walls. Table tops had already been changed to acoustically soft material before the intervention. The expected effect of the absorbents was a moderate reduction of the A-weighted equivalent sound level in the range of 3 dB, while the change of table tops, felt cushions and change of floor maths were hypothesised to mainly lead to less sounds resulting from interactions between surfaces occurring when e.g. plates and glasses are being put down on the table, or chairs being pulled over/on the floor. These types of sounds, hereon referred to as interaction sounds, would due to its short duration normally not be of large importance for the overall equivalent A-weighted noise levels in a preschool. However, as the head related transfer functions and impedance of the ear canals among preschool children result in an amplification of frequencies around 6kHz [3] these sounds may be perceived as very uncomfortable.

The room acoustic parameters reverberation time (T60s), and speech interference (STI) were measured in three random preschools before and after acoustic interventions. All measured rooms in the preschools had reverberation times in the order of 0.5 to 0.6 seconds before the interventions, and after the interventions the average reduction was in the order of 0.1 second. The measurements showed a greatest reduction in the frequency range of 250-500 Hz, which is in accordance with expected due to the addition of suspended acoustic panels with base reinforcement. The general increased absorption area of the rooms resulted also in higher dispersion seen as an increased Interaural-cross-correlation value (IACC). Generally there was also an improved Speech Transmission Index; (STI) however as for the reverberation time also the STI was very good before the interventions.

2.3 Monitoring of the sound environment

Noise levels were measured during daytime 07:00 to 18:00 during five weekdays per pre-school. Recordings were undertaken one month before the interventions and again three months after, using stationary measurements and personal dosimeters. Recording of the sound levels in the various rooms were done for two days per room category using a stationary sound level meter, B&K 2260 equipped with a ½ inch microphone. The system was acoustically calibrated before and after the measurement week using B&K 4231. The microphone was placed at a distance of 0.5 meter from the ceiling at a position where the activity noise would be representative for eating/activity room, and the playhall or playroom. Data were logged with 60 seconds time intervals, dynamic range of 30-110dB and with fast response time for minimum and maximum levels. Individual noise exposures were obtained from two children at a time, using dosimeters (SPARK 705+) and analyzed using BLAZE 5.06 software. Thirty seconds averaging intervals, a gain of 30dB, dynamic range of 43 -113dB and fast response time for minimum and maximum levels were used. Only time periods when the personnel and children took part in the pre-school usual activities and were indoors were used for these personal measurements and in the following referred to as Time indoors (Ti). The same procedure was undertaken in the control schools were no interventions were made.

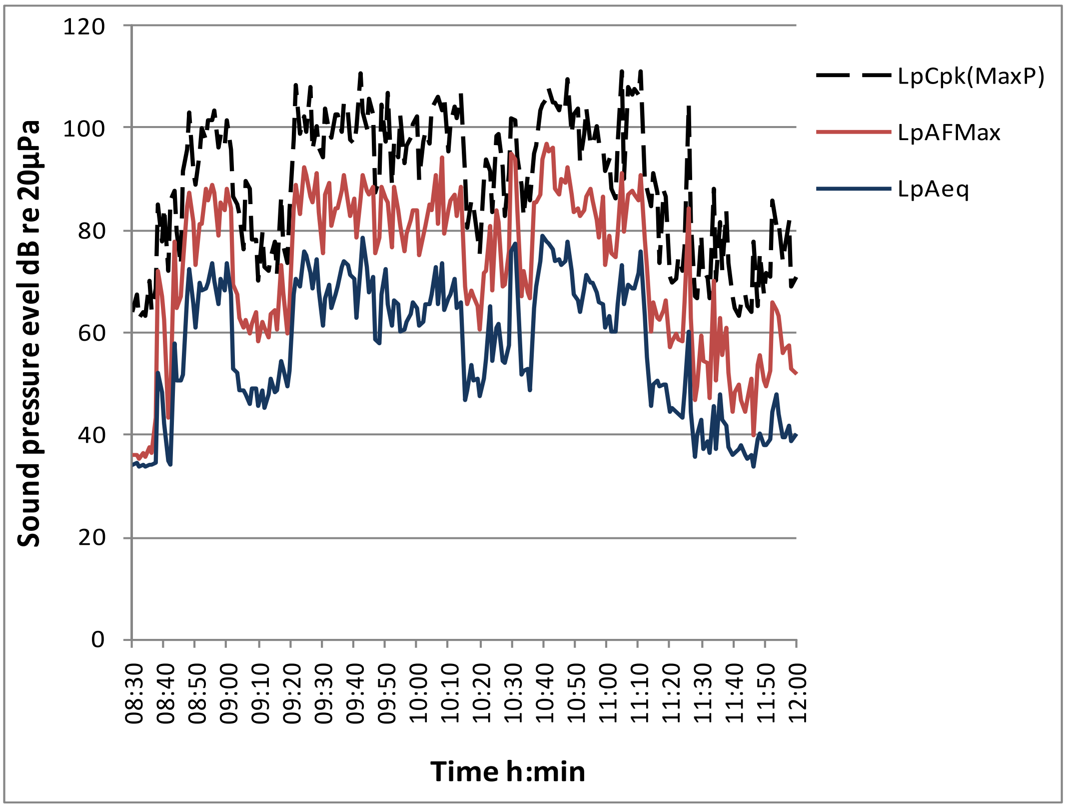

Figure 1: Typical distribution of sound pressure levels dB (LpCpeak, LpAFMax, LpAeq) in a play room in the morning.

The equivalent noise level over a whole day in the playroom, play hall and kitchen varies thus depending on the activities in these rooms. In order to cope with this highly variable condition we have adopted a method that analyses the periods when there is activity in the respective rooms. In the analyses the average length of a measurement period for the levels to become stable (t-test with 90% CI) was calculated. In our case, stable periods were derived after an average of 17 minutes to 22 minutes depending on the room. Using these averaged we calculated percentiles of time for sound levels in the rooms. In this study we used sound levels occurring less than 50% of the time, which we judge reflect activity in the rooms.

2.4 Procedure

One month before and three months after the intervention, the children in the intervention preschools were interviewed. In order to diminish the risk of inter-rater variance as much as possible the interviews were performed by two trained persons. The children were asked questions in a structured way and presented with visual representations of scales on show cards. When the child was not able to answer the question they were not prompted to do so. For details see Persson Waye et al [5]

2.5 Study population

Table 1 shows the distribution of age and gender of the children included in the analysis. The children included in the before and after study are fairly well distributed over gender and age groups. All children aged 4 to 6 years were asked to participate in the interview, the number of children that took part in the interview per preschool ranged from 4 to 15.

Table 1: Study population, before and after intervention

Characteristic	Before (resp. rate)	After (resp. rate)
Number of Respondents Children (%)	61(91)	55(88)
Gender		
girls	48%	49%
boys	52%	51%
Age		
4 years	52%	33%
5 years	48%	49%
6 years	-	8%
Number of Respondents parents* (%)	54(82)	44(69)

*Not included in this paper

2.6 Statistical analysis

Stationary noise levels measured in the two room categories in each preschool before and after the intervention as well as the dosimeter measures are presented using descriptive statistic. Generalised Estimating Equation (GEE) logistic regression models were applied to analyse the associations between different outcomes and relevant explanatory variables accounting for potential confounders and the repeated measures due to intervention (Before-After design) Compound symmetry structure was used for the working correlation matrix (Structure: Exchangeable). Three models were built, where <u>Model I</u> included equivalent stationary noise levels (before and after) as primary explanatory variable and children's sound perception, perception of teachers vocal behaviour, bodily sensation, sound source reaction and symptoms, as dependent variables. As only the sound source scraping, screeching sound was found significantly associated with the change of sound level, only this source was included in further analysis. <u>Model II</u> adopted children's perception of sounds as an indicator of measure of perceived noise, and perception of teacher's vocal behaviour, sound source reaction, symptoms as outcomes. Finally, <u>Model III</u> adopted bodily sensation as explanatory variable for reported symptoms. Dependent variables were calculated into binary variables by giving scale values 1,2,3 a score of 0 and 4, 5 a score of 1. The numbers 4 and 5 are interpreted as often and very often (perception and symptoms) or as much and very much (for reaction and wellbeing). For bodily reaction any bodily reaction to any sound was given a value 1 or none a value 0.

Potential confounding variables such as age and gender were included in all models. The results of regression analyses are given as odds ratios (OR) with 95% confidence intervals (CI). For simplicity, in this paper only p-values are presented. All statistical analyses were performed using IBM SPSS Statistics for Windows version 20.0 (IBM Corp. Armonk, NY, USA), applying two-tailed tests and a 5% level of significance.

3 Results

Table 2: Equivalent A-weighted noise levels measured in the eating/activity room and playroom for the intervention schools and the controls. Dosimeter values for children's noise exposure when being indoors (Ti)

	Eating/activity room			**Playroom**		
	Before	After	Diff	Before	After	Diff
Stationary					66.0	-2.7
Intervention, n=6	68.8	67.2	-1.6	68.7		
Controls, n=3	66.6	67.5	0.9	67.2	66.1	-1.1
Dosimeters		LAeq Ti			LAFmax	
Intervention*	85	83	-2	118	117	-1
Controls #	85	85	0	118	118	0

* n=61, before, n=55 after

\# n=18 before, n=20 after

Table 2 shows that the average levels in the intervention preschools were somewhat lower in the eating/activity room and playroom, but the difference was statistical significant only in the eating/activity room ($p<0.05$). The levels in the controls were not significantly different between the times for the before and after condition.

The children's exposure as measured by dosimeters were on average higher compared to the stationary measurements and in the range of 83-85 dB LpAeq and 117-118 dBAFmax, both at the intervention preschools and the control schools. No large difference was seen in either the intervention or the control preschools before and after the intervention, hence the intervention did not seem to affect individual noise levels in a measurable way.

Prevalence of the perception, reaction and symptoms before and after and the statistical outcome of the GEE logistic regression are presented in table 3.

Table 3: Prevalence of the perception, reaction and symptoms (often or very often and much and very much) and bodily sensation to any sound (yes) before and after and the statistical outcome of the logistic regression (GEE). Empty cells represent not applicable or p>.10

Dependent variable		**Before n=59-61**	**After n=54-56**	**Logistic regression GEE**		
		% (n)		Model I	Model II	Model III
Perception	Angry/ yelling sounds	66.7 (40)	58.2 (32)			
	Loud sounds	58.3 (35)	50.9 (28)			
	Scraping sounds	35.0 (21)	18.2 (10)	p<.05		
	Teacher yelling	26.2 16)	10.9 (6)	p<.05		
Reaction Sad	Scraping sounds	15.3 (9)	12.5 (7)		p<.10	
Reaction Angry	Scraping sounds	15.3 (9)	16.1 (9)		p<.05	
Symptom	Hoarse throat	16.7 (10)	7.3 (4)		p<.05	
	Tummy ache	23.8 (14)	20.0 (11)			p<.05
	Headache	19.7 (12)	22.3 (12)			p<.05
	Wellbeing	18.3 (11)	14.9 (8)			p<.05
Bodily sensation	Any sound	69.5 (41)	67.9 (38)			

Modell I - Stationary levels in the eating /activity room as explanatory variable

Modell II - Children's perception of scraping screeching sounds as explanatory variable

Modell III – Bodily sensation as explanatory variable

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4 Conclusions

The paper provides further data of the importance to acknowledge small children's specific noise exposure and perception. Sounds resulting from e.g. surface interactions being of high frequency characteristics, seem particularly harmful. Although the intervention affected the equivalent noise levels only marginally, it seems to have influenced sound quality aspects related to the higher frequencies as perception of scraping and screeching sounds were reduced accordingly. Also the perception of teacher yelling was reduced. The study lacks data of children's perception in the control preschools and hence conclusive evidence cannot be drawn. Nevertheless, the results are highly interesting, especially given the new knowledge of children's hearing.

Acknowledgments

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