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Effects of Acoustic Treatment on Music Teachers' Exposure to Sound

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In this study, music teachers' exposure to sound was tested by measuring the A-weighted equivalent sound pressure level (SPL), the A-weighted maximum SPL and the C-weighted peak SPL. Measurements were taken prior to and after acoustic treatment in four rooms during classes of trumpet, saxophone, French horn, trombone and percussion instruments. Results showed that acoustic treatment affects the exposure of music teachers to sound. Daily noise exposure levels ($L_{EX,\,8\,\mathrm{h}}$) for all teachers exceeded a limit of 85 dB while teaching music lessons prior to room treatment. It was found that the $L_{EX,\,8\,\mathrm{h}}$ values ranged from 85.8 to 91.6 dB. The highest A-weighted maximum SPL and C-weighted peak SPL that music teachers were exposed to were observed with percussion instruments ($L_{A\,\max} = 110.4$ dB and $L_{C\mathrm{peak}} = 138.0$ dB). After the treatments, daily noise exposure level decreased by an average of 5.8, 3.2, 3.0, 4.2 and 4.5 dB, respectively, for the classes of trumpet, saxophone, French horn, trombone and drums, and did not exceed 85 dB in any case.

Keywords: music teachers, sound pressure levels, acoustic treatment.

1. Introduction

Most frequently, people associate a musician's work with the pleasure of performing music; however, there are also negative aspects of this profession, since musicians may be exposed to high sound levels. The impact of high volume musical sounds on musicians' hearing may be comparable with the impact of typical industrial noise. Studies have demonstrated that musicians may experience hearing disorders associated with exposure to sounds, including tinnitus, hyperacusis or even hearing loss (Emmerich *et al.*, 2008; Jansen *et al.*, 2009; Pawlaczyk-Łusczyńska *et al.*, 2011), which may consequently interfere with their ability to perform in this profession. Aside from the musicians themselves, another profession at risk of excessive exposure is that of music teachers (Cutietta *et al.*, 1994; Mace, 2006; Owens, 2004; Behar *et al.*, 2004). Music teachers should avoid hearing disorders even more than the musicians themselves, since good hearing is essential when conducting classes.

Within the professions of musicians and music teachers, sound exposure cannot be eliminated since music is a useful signal; however, one should strive for lowering these musical sounds to the lowest possible acceptable level. Unfortunately, this cannot be achieved through the use of earplugs especially designed for musicians (Kozłowski *et al.*, 2011), since the use of earplugs by music teachers significantly hinders their ability to hear mistakes while their students are playing. Another possible means for reducing teachers' sound exposure is the application of acoustic treatment in the classrooms (Mikulski, 2013). The aim of this work was to examine whether acoustic treatment is also an effective solution for reducing the sound levels reaching the music teacher.

2. Acoustic treatment

Acoustic treatment was performed in 4 classrooms located in a music school in Warsaw. In room A with a volume of 53 m^3, trumpet classes were conducted. Room B (37.7 m^3) was used by saxophone and French horn teachers. In rooms C (41 m^3) and D (43.8 m^3), respectively, trombone and percussion classes were conducted. It was assumed that acoustic treatment would result in a change in the acoustic characteristics of the rooms characterised by a balanced reverberation time within a range of 125–8000 Hz, amounting to approx. 0.2–0.3 s, which would lead to a reduction in the sound level in the rooms concerned.

2.1. Panels and sound absorbing materials

Three types of resonant panels and absorbing materials were installed in all the rooms in order to enhance acoustic absorption. Resonant panels were installed on the walls of the rooms. Panels made of a 10 cm thick URSA AKP 3/V mineral wool with dimensions of 60 × 60 cm, placed in a wooden framing were installed in rooms A, B and C on the ceiling. In the room for percussion lessons, a modular ceiling made of 10 cm Rockfon Koral acoustic panels with dimensions of 60 × 60 cm were installed. In addition to the panels, velour curtains were placed in all the rooms on the walls with windows. Table 1 provides absorption coefficients for the panels and materials as applied for the treatment (Więckowska-Kosmala, Czechowska, 2012; Sadowski, 1976; catalogue URSA, n. d.; catalogue Rockfon, n. d.). Table 2 provides the surface area of the panels and absorbing materials as applied in the individual rooms.

Table 1. Absorption coefficient values for the panels and materials.

Panel/material	Frequency [Hz]					
	125	250	500	1000	2000	4000
Panel type 1	0.5	0.5	0.5	0.5	0.5	0.5
Panel type 2	0.4	0.5	1	1	1	1
Panel type 3	0.9	0.6	0.4	0.3	0.1	0.1
URSA AKP 3/V	0.65	1	1	1	1	1
Rockfon Koral	0.7	0.9	1	1	1	1
Velour curtains	0.14	0.35	0.53	0.72	0.7	0.65

Table 2. The surface area of panels and absorbing materials.

	Surface area [m^2]			
	Room A	Room B	Room C	Room D
Panel type 1	17.3	17.1	9	9.9
Panel type 2	1.8	0.8	4.1	7.4
Panel type 3	1.8	0.8	4.7	6.7
URSA AKP 3/V	8	4	4	–
Rockfon Koral	–	–	–	14.7
Velour curtains	10.8	6.7	8.5	5

2.2. Reverberation time

The reverberation time of all rooms was measured both prior to and after treatment in accordance with the ISO 3382-2:2008 standard. The results of the reverberation time measurements in individual rooms are provided in Fig. 1.

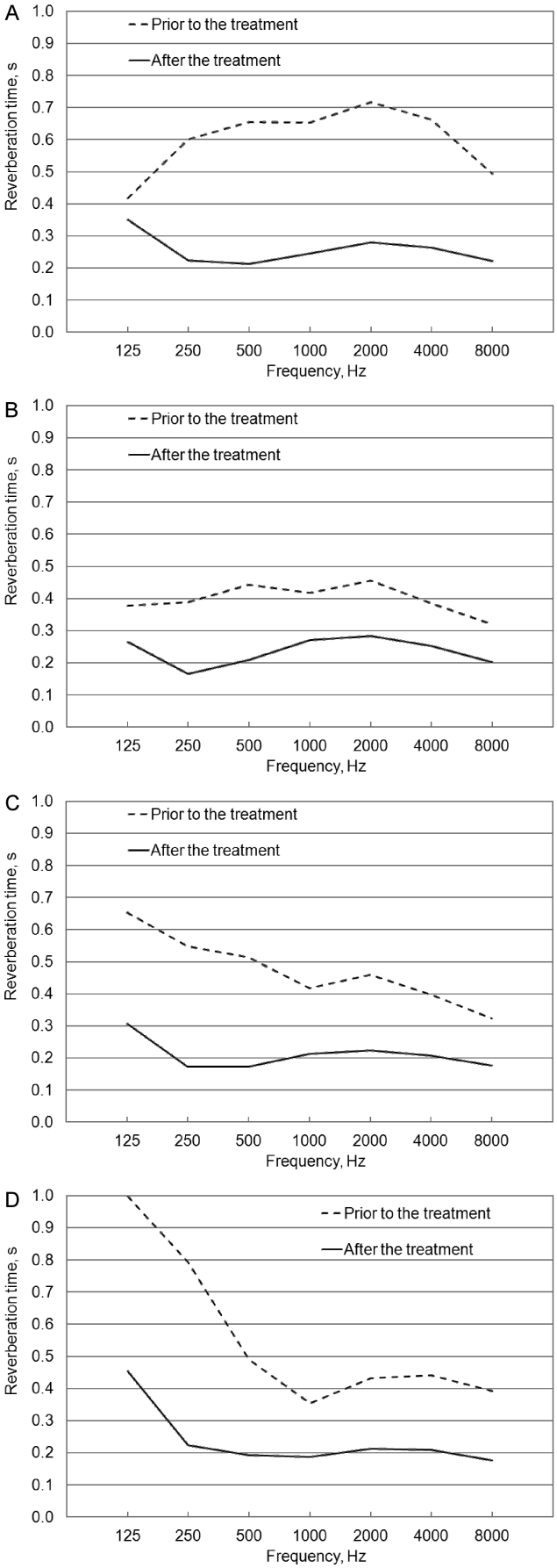

Fig. 1. Reverberation time of room A, B, C and D.

The greatest reduction in reverberation time was obtained in room A for trumpet classes. Reverberation time in the room prior to the acoustic treatment was from 0.6 to 0.7 s within a frequency range of 250–4000 Hz. Reverberation time after the treatment was approx. 0.2–0.3 s within the entire frequency range. Reverberation time in room B (saxophone and French horn classes), prior to the treatment was approx. 0.4 s for the frequencies of 125–4000 Hz. After the treatment, reverberation time was reduced to approx. 0.2–0.3 s. Application of acoustic treatment in room C, used by a trombone teacher, resulted in balancing and reducing reverberation time to approx. 0.2 s within a frequency range of 250–8000 Hz. Prior to the treatment, reverberation time for frequencies of 250 and 8000 Hz was approx. 0.5 s and 0.3 s, respectively. Initially, reverberation time in room D (percussion classes) was uneven: longer within a low-frequency range (0.8 s for 250 Hz) and shorter within a higher-frequency range (0.4 s for 8000 Hz). The acoustic treatment caused a reduction in reverberation time to approx. 0.2 s within a range of 250–8000 Hz.

3. Sound pressure level

Measurements of the sound pressure level (SPL) reaching teachers during classes were performed, both prior to and after acoustic treatment in order to determine its effectiveness.

3.1. Subject and scope of measurements

Five music teachers participated in the measurements: the trumpet teacher, using room A, the saxophone teacher (room B), the French horn teacher (room B), the trombone teacher (room C) and the percussion teacher (room D). A snare drum, xylophone and timpani were used during the percussion classes. Percussion instruments are special hazardous to hearing due to rapid onsets and impulsiveness of sounds emitted by them (Hamernik, Hsueh, 1991; Jaroszewski *et al.*, 2000). The *A*-weighted equivalent sound pressure level (L_{Aeq}), the *A*-weighted maximum sound pressure level ($L_{A\,\max}$), and the *C*-weighted peak sound pressure level ($L_{C\text{peak}}$) were measured. These parameters describe exposure limit values applicable at workplaces (Regulation of the Minister of Labour and Social Policy, 2002; European Directive, 2003). Measurements were performed using a SVAN 948 sound level meter equipped with a SVAN SV22 microphone and a SV 12L preamplifier. Measurements both prior to and after acoustic treatment were conducted at the same measurement points close to the teacher.

3.2. Results

Total sound pressure level measurements were performed during 35 classes. The measured values of L_{Aeq}, $L_{A\,\max}$ and $L_{C\text{peak}}$ are provided in Table 3. The table in question also provides the calculated values of daily noise exposure levels ($L_{EX,\,8\,\text{h}}$) and average values.

Measurements conducted prior to acoustic treatment showed the values of L_{Aeq} during all classes at more than 85 dB. Due to the long duration of exposure, the occurrence of such high L_{Aeq} means that limit values applicable in Poland (Regulation of the Minister of Labour and Social Policy, 2002) and upper exposure action values defined in European Directive 2003/10/EC of $L_{EX,\,8\,\text{h}}$ were exceeded for all music teachers participating in the tests. The average values of $L_{EX,\,8\,\text{h}}$ were: 89.1, 86.9, 86.5, 87.7 and 88.6 dB, respectively, for teachers of the trumpet, saxophone, French horn, trombone and percussion classes.

The L_{Aeq}, $L_{A\,\max}$ and the $L_{C\text{peak}}$ values were compared in order to present the effects of acoustic treatment on the improvement of the music teachers' working conditions. The L_{Aeq} values observed during the trumpet class prior to the acoustic treatment in room A exceeded a value of 91 dB. Acoustic treatment caused a reduction in L_{Aeq}, after which the level was not higher than 86 dB. The observed average $L_{A\,\max}$ and $L_{C\text{peak}}$ values after the acoustic treatment were respectively 5.3 and 3.6 dB lower. Measurements in room B during the saxophone classes prior to the acoustic treatment indicated an *A*-weighted equivalent SPL within the range of 85.8–88.5 dB. After the treatment, the L_{Aeq} values were lower than 85 dB, $L_{A\,\max}$ decreased on average, by 1.8 dB, and $L_{C\text{peak}}$ decreased by 2.5 dB. For the French horn classes, also conducted in room B, the *A*-weighted equivalent SPL obtained prior to the acoustic treatment was more than 87 dB. After acoustic treatment, the average L_{Aeq}, $L_{A\,\max}$ and $L_{C\text{peak}}$ values were lowered by 3.0, 3.1 and 2.6 dB, respectively. The L_{Aeq} measured during the trombone classes prior to the acoustic treatment were 87.5, 88.2 and 90.3 dB. After acoustic treatment, measured levels did not exceed 85.1 dB. The average $L_{A\,\max}$ and $L_{C\text{peak}}$ values were respectively lower by 3.2 and 0.7 dB. For the percussion classes, prior to the acoustic treatment L_{Aeq} exceeded 89.5 dB. Additionally, a measurement of $L_{C\text{peak}}$ performed during one class even exceeded 135 dB. Measurements performed in the acoustically treated room indicated that the L_{Aeq} and $L_{C\text{peak}}$ values respectively did not exceed 86 and 130 dB.

As a results of the acoustic treatment, the daily noise exposure level for all teachers participating in the tests was below the limit value (85 dB).

Table 3. A-weighted equivalent sound pressure level (L_{Aeq}), A-weighted maximum sound pressure level ($L_{A\max}$), C-weighted peak sound pressure level ($L_{C\text{peak}}$), and the exposure level as determined for the instrument classes ($L_{EX,8\,\text{h}}$).

Classes type (room)	Measurement		L_{Aeq} [dB]	$L_{A\max}$ [dB]	$L_{C\text{peak}}$ [dB]	$L_{EX,8\,\text{h}}$ [dB]
Trumpet (A)	Prior to the treatment	1	91.6	110.1	121.8	91.0
		2	88.9	107.3	118.7	88.3
		3	88.7	108.6	121.8	88.1
		Average	**89.7**	**108.7**	**120.8**	**89.1**
	After the treatment	1	85.2	103.2	118.9	84.6
		2	84.1	107.1	121.7	83.5
		3	83.7	101.6	114.7	83.1
		4	83.6	101.5	113.9	83.0
		5	83.1	103.7	116.7	82.5
		Average	**83.9**	**103.4**	**117.2**	**83.3**
Saxophone (B)	Prior to the treatment	1	88.5	103.2	116.6	87.9
		2	88.0	101.2	114.6	87.4
		3	87.7	101.4	119.6	87.1
		4	85.8	103.1	115.5	85.2
		Average	**87.5**	**102.2**	**116.6**	**86.9**
	After the treatment	1	83.9	102.7	115.9	83.3
		2	84.7	98.7	114.4	84.1
		3	85.0	100.5	113.3	84.4
		4	83.7	99.6	112.7	83.1
		Average	**84.3**	**100.4**	**114.1**	**83.7**
French horn (B)	Prior to the treatment	1	87.1	105.5	119.5	85.9
		2	88.4	106.1	121.0	87.2
		3	87.4	104.9	119.0	86.2
		Average	**87.6**	**105.5**	**119.8**	**86.4**
	After the treatment	1	85.0	103.2	117.1	83.8
		2	84.4	102.5	119.1	83.2
		3	84.3	101.5	115.5	83.1
		Average	**84.6**	**102.4**	**117.2**	**83.4**
Trombone (C)	Prior to the treatment	1	87.5	102.1	118.0	86.9
		2	87.2	104.1	118.5	87.6
		3	90.3	105.3	119.0	89.7
		Average	**88.3**	**103.8**	**118.5**	**87.7**
	After the treatment	1	83.1	97.4	117.9	82.5
		2	85.1	97.4	117.1	84.5
		3	85.0	99.8	115.9	84.4
		4	83.2	101.6	120.6	82.6
		Average	**84.1**	**100.6**	**117.8**	**83.5**
Percussion (D)	Prior to the treatment	1	88.5	110.4	138.0	87.9
		2	89.5	109.8	133.9	88.9
		3	89.6	107.3	130.4	89.0
		Average	**89.2**	**109.2**	**134.1**	**88.6**
	After the treatment	1	83.6	105.4	129.0	83.0
		2	85.2	106.9	125.5	84.6
		3	85.4	108.1	127.3	84.8
		Average	**84.7**	**106.8**	**127.3**	**84.1**

4. Summary

Application of treatment in rooms for instrument classes resulted in an increase in the acoustic absorption of these rooms, and thus the SPL reaching the music teachers decreased. Due to this acoustic treatment, the daily noise exposure level as determined for the teachers conducting classes in the treated rooms decreased, and no longer exceeds limit values.

In conversations, the teachers who participated in the study found they generally felt that the reduction in reverberation time did not cause problems with sound perception, and did not render conducting classes difficult. The teachers even concluded that after the acoustic treatment, mistakes made by students were in fact easier to hear.

This study indicates that acoustic treatment of rooms for instrument classes may be an effective means for the reduction of music teachers' exposure to noise.

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