

## ANALYSIS OF THE SOUND AMONG ORCHESTRAS AND HEARING DAMAGE IN MUSICIANS

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### ABSTRACT

The sounds of three orchestras (jazz orchestra, big folk orchestra and tamburitza-players folk orchestra) of the Radio-Television Belgrade were analysed. Separate analysis of each instrument was not made, but groups of instruments or the whole orchestras were analysed. If the sound produced by an orchestra as a whole is considered as a kind of noise it is apparent that each instrument produces a sound in the middle frequency range, which might represent hearing damage. A jazz orchestra produces the highest sound intensity level while both folk orchestras produce sound of more or less equal intensity.

Health examination of sixty musicians of Radio-Television Belgrade showed that the members of the orchestra and the conductor are exposed to sound levels which sometimes amount to 116 dB. Owing to the dynamics of music, a sound level is rather changeable and it is very difficult to compare it with industrial noise.

The modern way of living has created better conditions for life and work. Mechanisation and automation of work processes have reduced physical effort in work. However, the noise problem is becoming more and more serious, and it has been established that noise is one of the most widespread damaging factors in everyday life and at one's job. Industrial noise is present in almost all branches of industry, its characteristics depending on the type of industry, so that noise fighting has been going on at all levels.

Apart from noise in industry, urban environments and others, so far little attention has been given to the effects of high intensity sound on the hearing of professional musicians. In the musical profession there is daily irritation of the sense of hearing and of the entire organism, regardless of the pleasures such work brings with it. The problem of noise effects is outstanding in work with musical instruments, as physical protection from this kind of noise is impossible. Under certain circumstances the sound of an orchestra can produce pleasant and unpleasant sensations, depending on how this sound is received. The sensorial perception of sound depends on the nature of the sound waves. The simple regular vibration of sound waves produces tones, a conglomeration of rhythmical flexions of a medium, when the basic tone is succeeded by a series of harmonious tones producing sound.

The influence on man, as a psychophysical being, subject to pleasant and unpleasant sensations, sensitive to various influences, which may be useful or deleterious to the organism as a whole or its constituents depends on the height, intensity, colour and duration of sound.

In music, one cannot really talk of noise in the proper sense of the word, as noise is defined as an undesirable sound, so that routine criteria have not been applied in estimating the damaging effects of noise. However, the members and conductors of orchestras are sometimes exposed to sound levels up to 116 dB. Due to the dynamics of music, the sound level greatly varies, so that a comparison with industrial noise is rather difficult.

#### SUBJECTS AND METHODS

In the analysis of noise carried out in the orchestras of the Radio-Television Belgrade (RTB), each instrument was not dealt with separately, but in groups or as the entire orchestra. This means accords or "tutti", were subjected to analysis.

In order to ensure an early detection of fatigue and damage of hearing the musicians of the Radio-Television Belgrade, have been subjected to audiological checks and examinations for years.

The project covered a group of 42 musicians playing in the orchestras of the Radio-Television Belgrade. They were included in a complete examination in 1973 and 1977. In 1973 in the group under 25 years of age, there were 14.3% musicians, and in the over 50 group none. In 1977 the limits shift, so that there were no members in the under 25 group, and 11.9% in the 50 to 55 age group (Table 1).

TABLE 1  
Number of musicians taken in the study by age.

Year	Total	Age groups						
		21-25	26-30	31-35	36-40	41-45	46-50	51-55
1973	42	6	4	8	10	9	5	0
1977	42	0	6	4	8	10	9	5

The analysis of exposure during years of service shows that in 1973 and 1977 the percentage of musicians with 10 years of service was the same (19%). The largest number of musicians in both time periods was in the group with 11 to 20 years of service, while in 1973 there were none with over 30 years of service, and in 1977 only 4.8% (Table 2).

TABLE 2  
Number of musicians in the study by length of exposure.

Year	Total	Years of service			
		<10	11-20	21-30	>30
1973	42	8	27	7	0
1977	42	8	19	13	2

## RESULTS AND DISCUSSION

If the sound of an orchestra is considered integrally, that is as a certain kind of noise, one can see that the constituents are in the medium frequency range, which, depending on the sensitivity of the sense of hearing, might cause impairment to hearing.

The distribution of constituents depends on the tonality of the orchestra's playing, so that this too has to be taken into account in interpreting the spectrum obtained. In other words when the same composition is played in a different tonality, the spectrum shifts along the frequency axis, the ratio of constants remaining identical.

The highest intensity, the highest sound level is produced by a jazz orchestra, followed by the symphony orchestra, while the sound level is slightly lower in folk orchestras (Table 3). The octave analysis confirmed that the highest

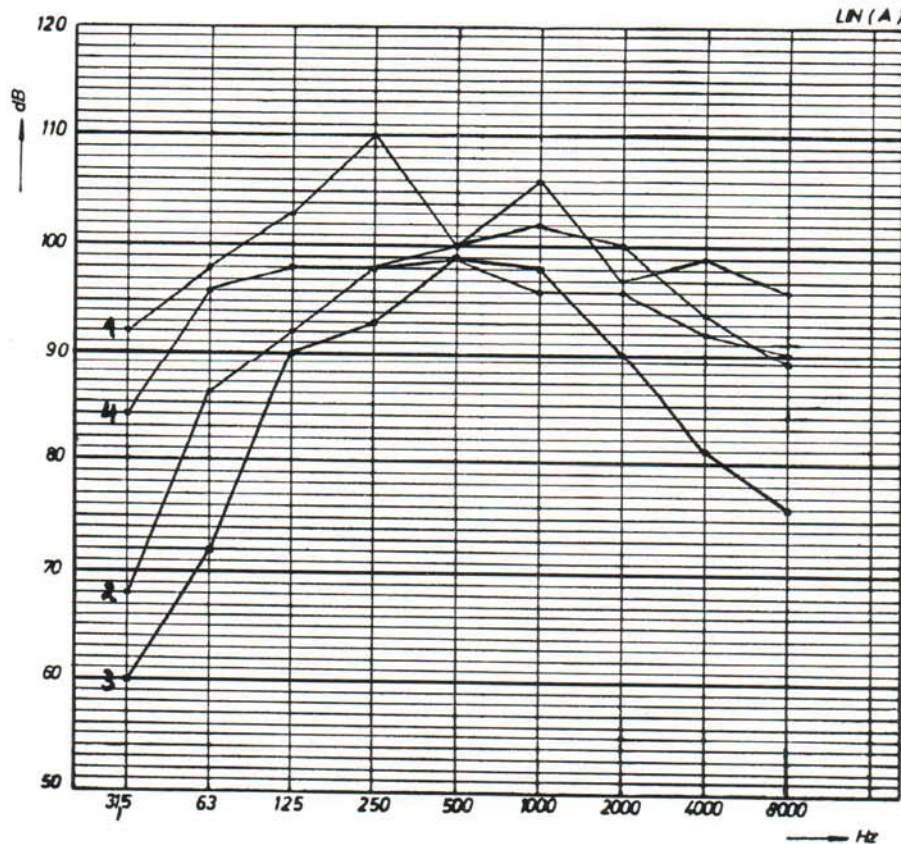


FIG. 1 - Analysis of sound produced by a jazz orchestra. Top levels of sound pressure produced by drums (1), brass (2), saxophones (3) and entire orchestra (4).



levels of sound pressure are in the medium frequency range from 500 to 4 000 Hz (Fig. 1 and 2).

The audiometric analysis in 1973 revealed normal hearing in 27 musicians a slight loss in four, a moderate loss in six and a serious loss of hearing in five musicians. The results of audiometric examination in 1977 are shown in Table 4. Out of the total of 42 musicians in RTB orchestras 23 musicians or 54.8% had normal hearing, and 19 or 45.2% impaired hearing.

Analysing years of service with exposure in relation to impaired hearing we found the highest number with impaired hearing (8 musicians) in the group of 11–20 years of service (3 with a slight loss, 3 with a moderate loss and 2 with a serious loss of hearing). In the group of 21 to 30 years of service there were 7 musicians with impaired hearing (1 with a slight loss, 2 with a moderate loss and 4 with a serious loss of hearing). Among musicians serving less than 10 years,

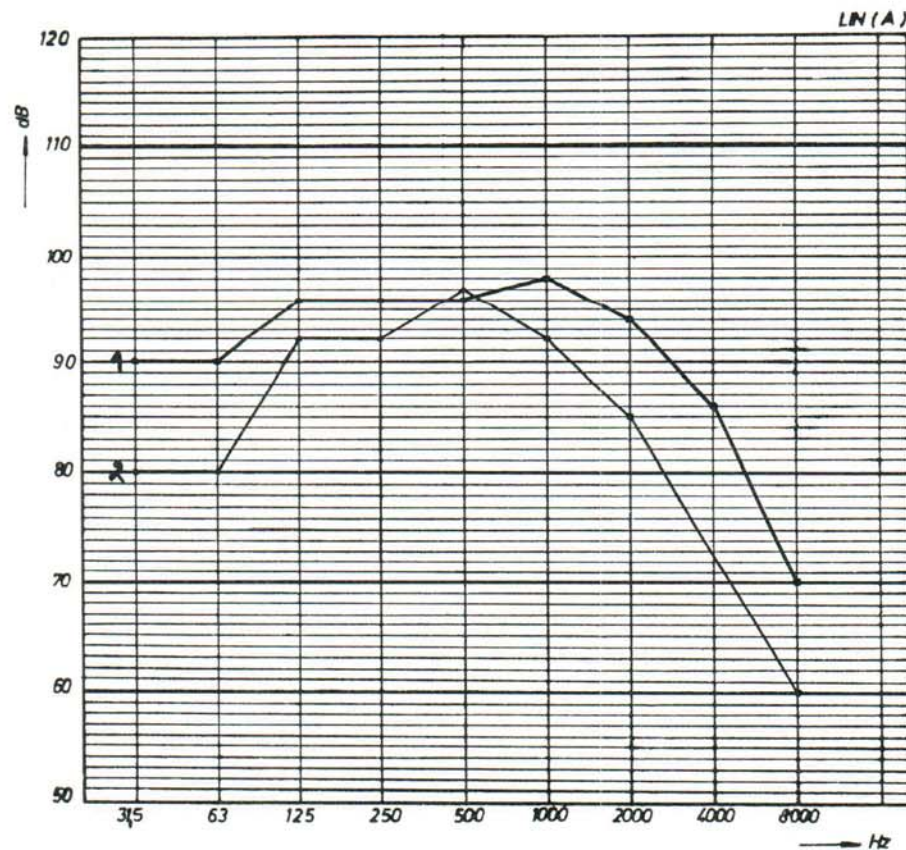


FIG. 2 – Analysis of sound produced by a symphony orchestra. Top levels of sound pressure recorded in front of the brass (1) and at the string instruments (2).

TABLE 3  
The analysis of sound measurements in the RTB orchestras.

Orchestra	Source of sound	Total sound level (dB)
Jazz	Drums	104-110
	Trumpets	105-109
	Saxophones	95-96
	Entire ensemble*	98
Symphony	Wind group (trumpets, trombones, horns)	80-106
	String	76-78
	Entire ensemble*	91-95
Big folk	Recording of folk song by base baritone	80-86
	Alto singing*	up to 88
	Pronounced bassoon and voice (alto)	up to 88
	Voice (alto) expressed in orchestral accompaniment	up to 92
	Group of wind instruments (clarinet)	up to 82

\*at conductor's place

three had impaired hearing (2 slight and 1 serious) and of the two musicians serving more than 30 years one had only slightly impaired hearing.

The analysis of the ratio between the length of exposure during years of service and the lesions established shows that the number of musicians with impaired hearing increases with years of exposure during service and years of age, ie. there is a shift to the right. It must be taken into consideration that a period of 5 years is not long enough for taking the years of age as a yardstick for a serious loss of hearing, and that most of the musicians were under 50 (only 5 musicians over 50 years of age). We therefore consider that in this case the ageing of musicians cannot be the only cause of the considerable incidence of musicians with a loss of hearing, and that this must be due to the effects of high sound levels during orchestral performance and constant irritation of the sense of hearing during work hours.

TABLE 4  
Audiometric findings in musicians in 1977.

Age (years)	Hearing				Total
	Normal	Slight loss	Moderate loss	Serious loss	
up to 30	6	0	0	0	6
31-40	7	2	2	0	11
41-50	9	5	3	3	20
over 50	1	0	0	4	5
Total	23	7	5	7	42

We consider that the health of musicians, especially the state of their hearing requires regular medical check-up. Deleterious effects of high sound levels in orchestral music, the quality and type of noise, the lower and upper limits, duration of daily, weekly, and total exposure during life, the range of hearing deficiency and frequencies and many other elements which may endanger the musicians' working abilities or cause early disablement should be carefully controlled.