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Comparison between Opera houses: Italian and Japanese cases

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ABSTRACT

Opera houses acoustics differ from concert halls, since Opera requires more clarity and intelligibility than music. Furthermore, usually opera houses were built in Italy, since opera has a strong tradition in towns such as Venice, Parma, Bologna. However, historical Opera houses were built also in other Countries, especially in Japan, even though Japanese traditional opera was completely different from Italian one.

In this paper a comparison between an Italian Opera house (Teatro Alighieri in Ravenna) and a Japanese Noh theatre (in Kobe, Japan) are presented. Experimental measurements were conducted in both the theatres by means of the same instrumentation, i.e. dummy head (Neumann), a 3D microphone (Soundfield), and an omni-directional loudspeaker.

The calculation of mono-aural and binaural parameters showed a different behavior between the two theatres, which has been related to the different shape of the audience area.
KEYWORDS : Opera houses, Measurements, comparison,

INTRODUCTION

In room acoustics Opera Houses represent special environments where sound properties differ from other auditorium and theatres. Besides, normally Italian opera houses are considered, and their special shapes, like balconies, stage are analyzed. Furthermore, the acoustical

properties of coupling effects between the volumes of main hall and stage, as well as radiation waves on the floor, are usually investigated.

Italian Opera Houses are strongly related with traditional Italian musical production, which especially in 18th and 19th centuries was related with opera. On the other hand, Japanese Noh theatres are linked to traditional Japanese Noh drama, which constitutes an analog ancient tradition like Italian opera. Since in both cases music and speech are accomplished, a comparison between acoustical properties has been carried out.

The Italian opera house Teatro Alighieri, in Ravenna, Italy, and the Japanese Noh Drama Theater in Kobe, Japan, have been analyzed.

METHODS OF ACOUSTICAL ANALISYS

During the acoustical measurements the following instrumentation was utilized:

- An omni-directional, frequency-equalized sound source (namely LookLine) was utilized in both the theatre. In Noh theatre a smaller, modified sound source was utilized [6].
- A dummy head was positioned at the receiver's positions (Neumann KU-100). In Alighieri theatre an other dummy head (Sennheiser) was utilized during the measurements. It allowed the measurements of binaural parameters
- A Soundfield microphone (MK V in Ravenna and ST-250 in Kobe) probe accomplished the dummy head in both theatres. The 4 channels output were utilized during the calculation of monoaural and 3-dimensional parameters

A log sine sweep was utilized in both the theatres. In Alighieri Theatre a sweep 20 seconds long, ranging from 40 Hz to 20 kHz, was generated, whereas in Noh theatre the sweep was 15 seconds long, and it ranged between 22 Hz to 22 kHz. The two sweeps were slightly different each other because of the slight differences between the two sound source utilized.

In both cases the signals coming from the microphones were directly stored in the PC by means of a 20 bit 96 kHz 8 channels soundboard.

In the Alighieri theatre the measurements were conducted in 22 different positions, ranging from stalls to balconies. The sound source was positioned in the stage and then the measurements were repeated moving the sound source into the orchestra pit. A reference position at 1 meter was added, in order to compute spatial maps of strength.

Figure 1: the two theatres during the measurements: Alighieri (Left) and Noh Drama (right)

In Noh drama theatre the measurements were conducted locating the sound source into two positions, and the microphones in other two places. In this case the Soundfield and dummy head were positioned onto a rotating table, as described in [6].

RESULTS OF MEASUREMENTS

From the measurements many different acoustical parameters were calculated. In tab. 1 the mean values obtained in the two theatres are represented.

Even though the two methods applied differed for the microphonic arrays, the monoaural parameters calculated from the several impulse responses measured underlined some similarities between the two halls.

In both theatres the reverberation time was about 1 second. However, in Alighieri theatre it was decreasing in frequency, as usually happens in Italian opera houses where reverberation time sharply decreases with frequency, whereas in Noh theatre it was quite uniform in frequency domain, especially Early Decay Time.

Frequency	31.5	63	125	250	500	1k	2k	4k	8k	16k	Lin	A
NOH												
C50 [dB]	0.2	-1.5	0.3	-2.2	-1.6	-1.7	-2.2	-1.6	2.7	8.2	0.7	-0.3
C80 [dB]	1.2	3.8	4.3	2.5	2.0	1.7	1.5	2.2	6.8	14.0	4.1	3.2
D50 [%]	51.9	42.6	51.7	39.6	41.4	40.5	37.6	41.2	64.3	86.1	54.0	48.6
Ts [ms]	82.0	105.4	75.8	80.9	81.2	88.4	90.5	79.5	47.0	22.9	64.2	71.7
EDT [s]	1.3	0.8	0.9	0.8	1.0	1.2	1.1	1.0	0.6	0.4	0.9	1.0
T20 [s]	2.1	1.4	0.7	0.7	1.0	1.1	1.1	0.9	0.6	0.4	1.0	1.0
LF											0.50	
IACC											0.20	
ALIGHIERI												
C50 [dB]	1.8	-3.9	-3.7	0.5	2.3	2.7	3.2	3.0	4.3	7.7	3.3	3.4
C80 [dB]	4.3	-0.7	0.1	3.5	5.0	5.8	6.2	6.4	8.8	12.9	6.6	6.7
D50 [%]	57.7	31.1	31.5	52.4	62.1	64.4	66.2	64.9	71.5	83.5	66.7	67.1
Ts [ms]	110.0	156.3	138.5	83.0	59.2	53.5	49.6	49.5	37.0	23.1	47.4	46.4
EDT [s]	1.7	1.8	1.8	1.3	1.1	0.9	0.9	0.8	0.6	0.5	0.8	0.8
T20 [s]	3.2	2.1	2.0	1.6	1.2	1.1	1.0	0.9	0.7	0.5	1.1	1.0
LF											0.28	
IACC											0.34	

Table 1: acoustical parameters (average) measured in the two theatres

The energetic parameters, like Clarity C50 and C80, and Center time, *Ts*, were significantly different between the two theatres. At mid frequencies (500 Hz – 2 kHz), Clarity C50 ranged from 2.3 to 2.7 in Alighieri theatre and from –2.2 dB to –1.6 in Noh theatre, Clarity C80 from 5.0 to 6.2 dB in Alighieri and from 1.5 to 2.0 dB in Noh. Finally, Center time varied from 49.6 to 59.2 ms in Alighieri and from 81.2 to 90.5 ms in Noh theatre.

The values obtained in Alighieri theatre were in agreement with other acoustical parameters like reverberation time, and with previous experimental data. The values were also

well distributed inside the theatre, and spatial parameters like LE, increasing moving towards balconies showed the influence of lateral reflections in sound quality.

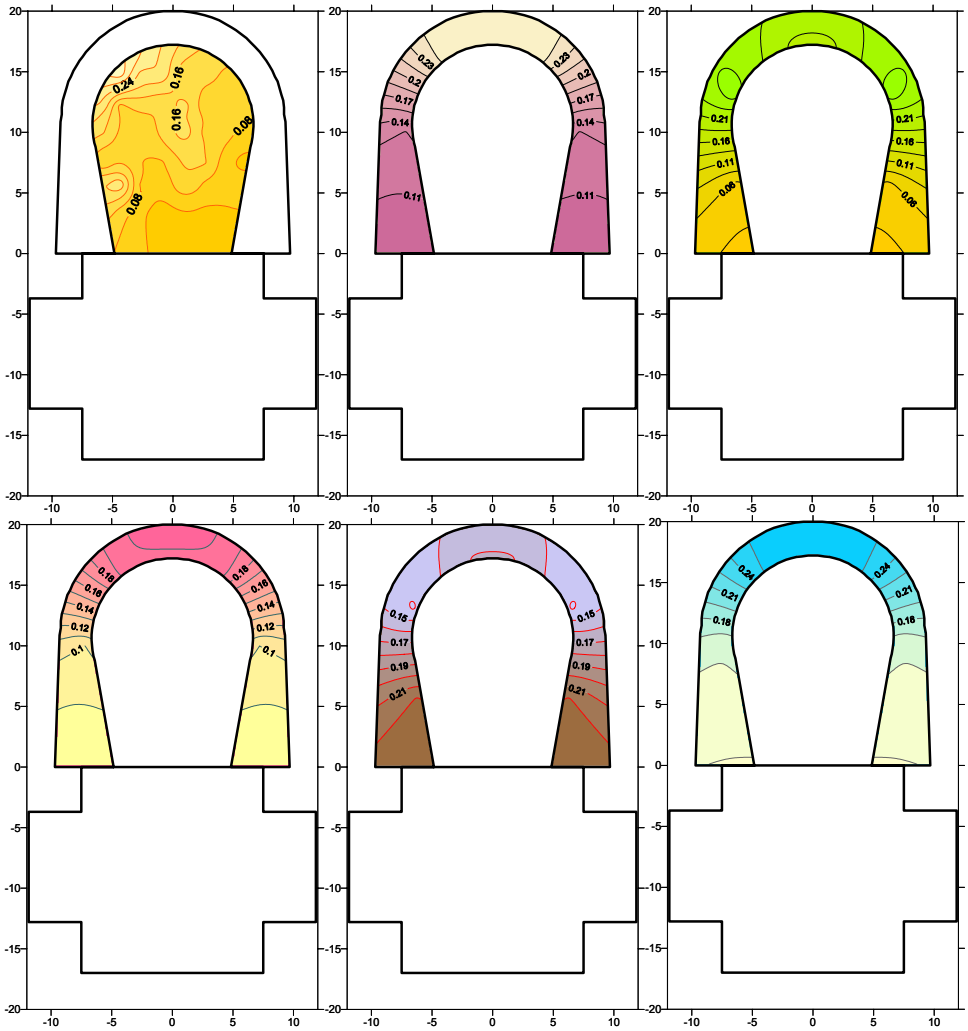

Figure 2: Theatre Alighieri; maps of Lateral Efficiency (LE). From above: left: stalls; balcony 1st and 2nd order. Below: balcony 3rd, 4th and 5th order

Furthermore, the high values of Clarity (especially C80), and consequently the low values of Center time, revealed a typical behavior of Italian Opera houses, which are characterized by a short reverberation time and high intelligibility, which is most important for speech rather than for music.

In the Noh theatre, on the other hand, reverberation time was very similar to Alighieri, even though slightly lower, but Clarity (both C50 and C80) was much more lower. Therefore, the short reverberation time of the theatre, requested for a good intelligibility of speech was not influencing the reverberation tail of the impulse responses, which guarantee a good sound envelope suitable for musical performances.

The different dimensions and shape of the two theatres, shown in figure 1, probably caused the different behavior of the two Opera houses. It provoked a different energy distribution in the impulse responses, and acoustical parameters related to early/late energy

ratio were therefore quite different.

CONCLUSIONS

In this paper the acoustical properties of two different halls (a classical Italian Opera House, and a typical Noh theatre) have been compared. The same experimental technique has been utilized in order to measure impulse responses.

Even though data collection was slightly different in the two cases (several points in the stalls and in the balconies in the Opera house; a rotating table positioned in 2 points in the Noh theatre), a comparison between the two halls underlined different properties especially in the reverberation tail, which provoked a great variability in early/late energy ratio between the two theatres.

Further experiments will be carried out by means of auralisation and comparing the two different sets of impulse response with other halls throughout the world, in dedicated listening rooms, available at University of Bologna and ASK [5], [6].

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