STAGE SET AND ACOUSTICS IN A BAROQUE-TYPE OPERA HOUSE

SS-RBA-01

Iannace Gino[1], Ianniello Carmine[2], Maffei Luigi[1], Romano Rosario [2]
[1] DISPAMA – Second University of Naples, Faculty of Architecture
Borgo S. Lorenzo, Aversa 81031 (Caserta), Italy, Tel. +390818142166, Fax +390818148626, luigi.maffei@unina2.it
[2] DETEC - University of Naples FEDERICO II - Faculty of Engineering
P.le Tecchio 80, 80125 Naples, Italy, Tel. +390817682296, Fax +390812390364, ianniell@unina.it

ABSTRACT

Different sceneries fitted in the stage-house of an opera house may yield different room-acoustics conditions for the listeners. The changes depend on the nature of the fittings. This paper discusses the results of acoustic measurements carried out in the unoccupied Teatro di San Carlo in Naples (Italy) in the aim of quantifying the effects of three different sceneries on usual mono-aural objective parameters. The analysis of data suggest only significant little changes due to the observed sceneries.

INTRODUCTION

This preliminary study was stimulated by a statement that is reported from time to time in the literature on opera house acoustics, that is: different sceneries fitted in the stage-house yield different room-acoustics conditions for the listeners. These changes depend on the nature of the fittings in the stage-house. For example, with reference to the auditorium of the Munich National Theatre which was observed once with a reverberant stage-house and once with the stage-house highly absorptive, Cremer [1] commented: "*Often these extreme values of reverberation contradict the kind of acoustics suggested by the scenery: the "teure Halle" that Elizabeth praises in "Tannhauser" usually is quite free of reverberation, whereas for the open-air festival in "Die Meistersinger", the rather reverberant stagehouse makes it clear that this scene is not played outdoors - which is not disadvantage, musically!".* It is not clear if the casual listener would notice this, but lesser changes of the stage-house scenery could result into measurable changes of objective descriptors of the acoustics of a theatre. This paper reports a contribution to the above-mentioned topic. The authors analyse and discuss the results of acoustic measurements carried out in the unoccupied Teatro di San Carlo in Naples (Italy) [2] in the aim of quantifying the effects of the change of three sceneries.

ACOUSTIC MEASUREMENTS AND DATA ANALYSIS

Three sets of data were obtained on the occasion of three opera concerts: the Tannhauser by R. Wagner, La Sonnambula by V. Bellini and Tancredi by G. Rossini. Different sceneries were fitted in the stage-house. For the Tannhauser the bare stage-house was fitted with four large columns. They were made of wood and had a polygonal section. For La Sonnambula a white hall made of wood was installed. It had non-continuous ceiling and walls. This configured a sort of partial shell that reduced the acoustic coupling of the large volume of the stage-house with the auditorium in a certain degree. For Tancredi the scenery was constituted of a high relief of papier-mâché representing a heap of giant helmets and masks. Four plain wings of black canvas were fitted at each side of the stage. Figure 1 shows a view of each stage condition when measurements were carried-out.

Tannhauser La Sonnambula Tancredi

Fig.1 – View of the stage of the Teatro di San Carlo with different stage fittings.

Impulse responses were recorded always with the same MLSSA$^{@}$-based measurement system [3]. In the case of Tannhauser, fourteen listener locations were considered. Eight were distributed in the right side of the stalls and six at the front of six boxes. A first pair belonging to the second tier, a second pair to the third tier and a third one to the fourth tier. Two locations of the dodecahedral sound source were considered; the first one on the central axis of the stage floor, 3 m behind the proscenium arch, and the second one at the centre of the pit floor. This yielded 28 different source-receiver pairs. In the case of La Sonnambula, seven listener locations were considered. Four were distributed in the right side of the stalls and three at the front of three lateral boxes belonging to the first, the second and the third tier, respectively. The sound source was located a first time on the stage in the same location chosen for Tannhauser. A second time was shifted to a location 3 m to the right and further 3 m from the proscenium arch with respect to the first one. The third time the dodecahedral sound source was located on the pit floor shifted to the right with respect to its pit location for Tannhauser. This yielded 21 different source-receiver pairs. As receiver and sound source locations were not coincident perfectly for these two settings of the stage, and relevant data were already available, a larger number of listener and sound source locations was considered on the occasion of the performance of Tancredi. This allowed including both the previous sets of source-receiver locations in this last set of measurements (49 source-receiver pairs). So, a direct comparison of the effects of scenery change could be made for the corresponding pairs Tancredi-Tannhauser and Tancredi-La Sonnambula.

Usual acoustical objective parameters were computed from the impulse response corresponding to each source receiver pair. Although more objective parameter were calculated, for the sake of brevity only RT, EDT, G, C_{80} and C_{50} for the octave bands having the centre frequency f from 125 to 4 kHz are discussed herein.

The calculated objective parameters were grouped in the attempt to evaluate the difference between corresponding values due solely to a change of scenery in the stage-house. As reported previously, comparisons could be carried out only for source-receiver pairs common to Tancredi and Tannhauser and pairs common to Tancredi and La Sonnambula. Therefore, a grouping of data was needed to get rid of the influence of the sound-source location. For clarity, Table 1 summarizes how five pairs of data-block were obtained for calculating the difference between each objective mono-aural parameter pair.

Table 1 – Summary of data grouping.

Sceneries	Sound-source location	Receivers	Octave bands	Parameters	N. data
TD – TS	Centre of the stage	14 + 14	6	5	420 + 420
TD – TS	Centre of the pit	14 + 14	6	5	420 + 420
TD – BL	Centre of the stage	7 + 7	6	5	210 + 210
TD – BL	Half right of the stage	7 + 7	6	5	210 + 210
TD - BL	Half right of the pit	7 + 7	6	5	210 + 210

The number of data in the last column in Table 1 yielded the differences of the octave-band values of the considered objective parameters for each scenery pair reported in the first column, e.g. C_{80}(1 kHz) for Tancredi scenery minus C_{80}(1 kHz) for Tannhauser scenery for the same sound source and receiver locations. These differences were inspected visually to discover ordered general trends but, although substantial differences existed in many specific cases, no clear trend was observed in general.

The analysis of the measured reverberation times revealed that the values for Tannhauser were higher than those for Tancredi on average. Fig.2 (a) reports the comparison obtained by plotting all RT(f) values corresponding to the two sound-source locations in the first two rows of Table 1. As shown in Fig.2 (b), the same happens for the values of RT(f) of La Sonnambula with respect to Tancredi. All available RT(f) values corresponding to the last three rows of Table 1 are used in the plotting. For clarity, only three symbols are used. LF stands for the octave-bands at 125 and 250 Hz, MF is related to the octave-bands at 500 and 1k Hz and HF stands for the octave-bands at 2k and 4k Hz.

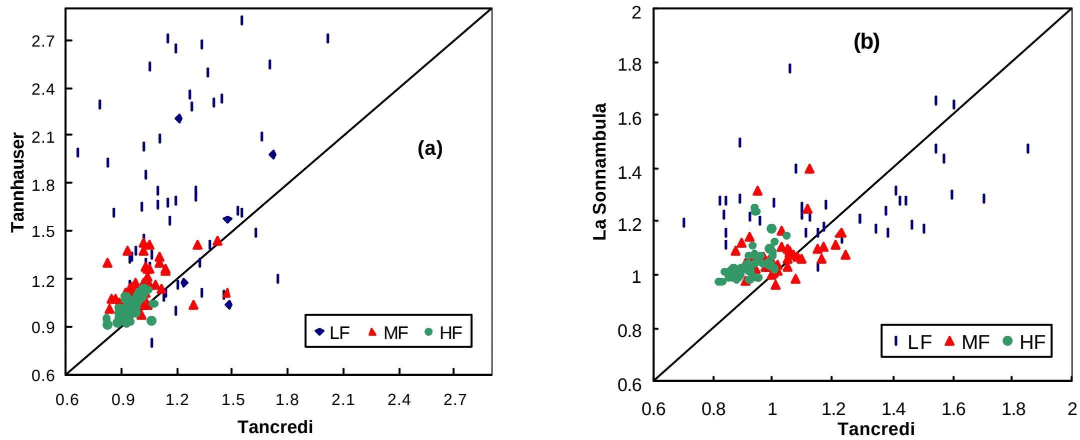

Fig. 2 – Reverberation time comparison. (a) Tannhauser vs. Tancredi, (b) La Sonnambula vs. Tancredi.

Fig.3 (a) shows the histogram of the statistical distribution, and its cumulative, of the difference ΔRT(f) for the pair Tancredi-Tannhauser. It shows an average dominance of the reverberation time of Tannhauser with respect to Tancredi. Analogous information for Tancredi-La Sonnambula is reported in Fig.3 (b). In this case, the reverberation times for La Sonnambula are a little higher than those for Tancredi.

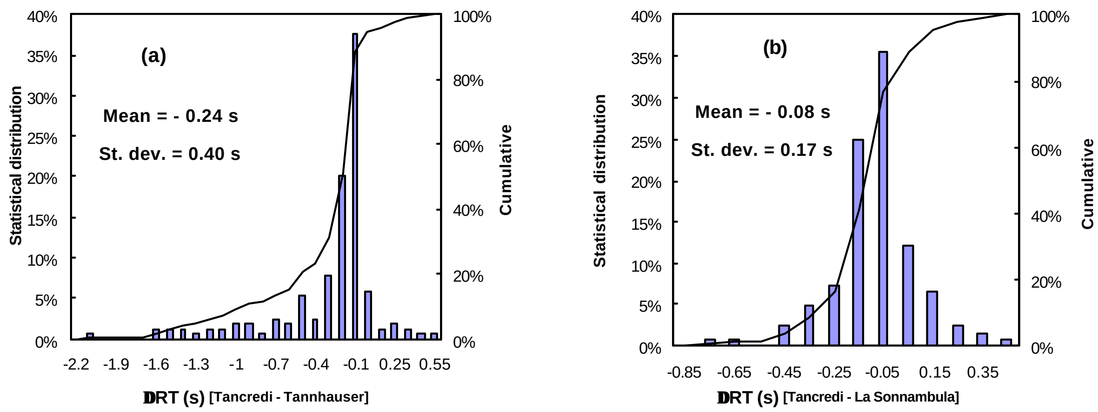

Fig. 3 – Statistical distribution, and cumulative, of the difference between reverberation times. (a) Tancredi-Tannhauser, (b) Tancredi-La Sonnambula.

To gain a deeper insight into these results a two-way-with-interaction ANOVA (TWI-ANOVA) treatment was applied to the data presented in Fig.2 after they were divided into groups according to the measurement octave-band. The investigated factors were the scenery and the sound source location. The results showed that in the case of Tannhauser-Tancredi the hypothesis H_0 could be rejected at all frequencies for the scenery factor while for the sound-source location factor this hypothesis could not be rejected at 125 Hz and 250 Hz. This means that the influence of the scenery is significant at all frequencies while the sound source location is significant only for the octave bands at 500, 1k, 2k and 4k Hz. The same analysis was applied to the reverberation time for the pair Tancredi-La Sonnambula. It disclosed that the sound-source factor was not significant at all frequencies, while the scenery factor was significant at 1, 2, and 4 kHz.

As regards the early decay time, Fig.4 (a) reports the comparison Tannhauser-Tancredi obtained by plotting all EDT(f) values corresponding to the two sound-source locations in the first two rows of Table 1. Fig.4 (b) presents the analogous comparison for La Sonnambula with respect to Tancredi. All available EDT(f) values corresponding to the last three rows of Table 1 were used in the plotting. Histograms of the statistical distribution, and its cumulative, of the difference ΔEDT(f) for the pairs Tancredi-Tannhauser and Tancredi-La Sonnambula are reported in Fig.5 (a) and (b), respectively.

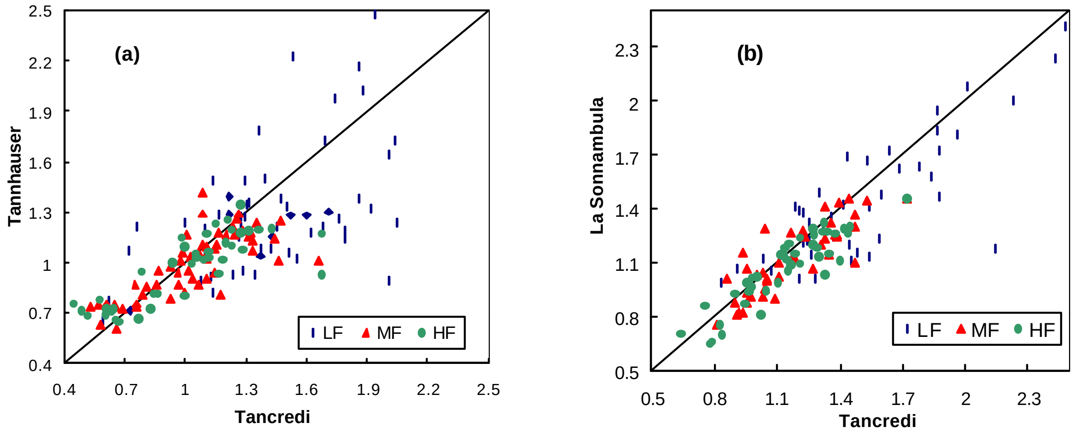

Fig. 4 – Early decay time comparison. (a) Tannhauser vs. Tancredi, (b) La Sonnambula vs. Tancredi.

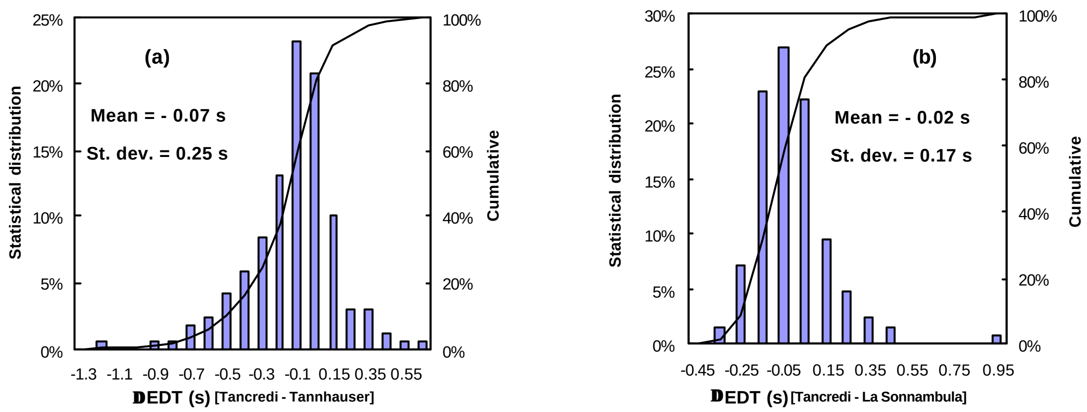

Fig. 5 – Statistical distribution, and cumulative, of the difference between early decay times. (a) Tancredi-Tannhauser, (b) Tancredi-La Sonnambula.

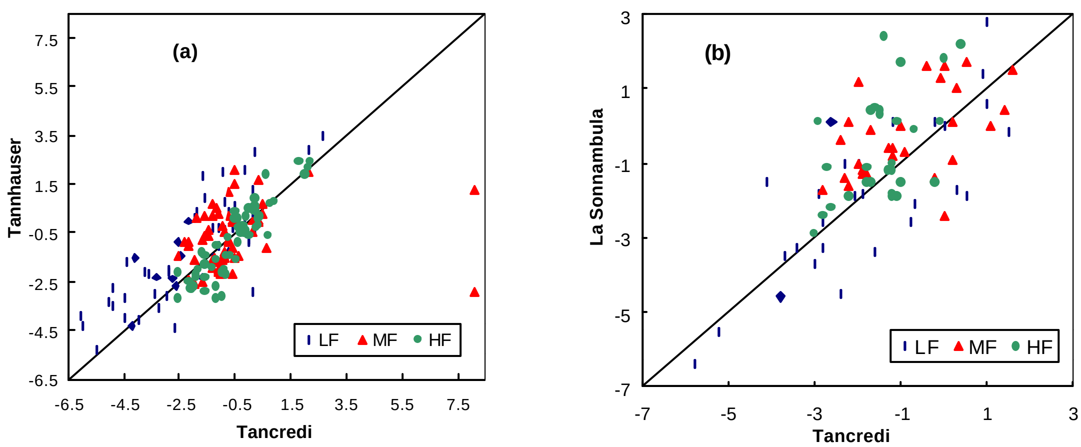

Fig. 6 – Comparison for G(f). (a) Tannhauser vs. Tancredi, (b) La Sonnambula vs. Tancredi.

With respect to Tancredi-La Sonnambula, low frequency values of EDT(f) for Tancredi-Tannhauser appear more scattered around the equality-line. However, only average negligible difference are observed in both comparisons. The TWI-ANOVA analysis showed that neither the source factor nor the scenery factor had a significant influence on EDT(f) for both the cases at all frequencies. Fig.6 and the following figures report the previous graphical information for G, C_{50} and C_{80}.

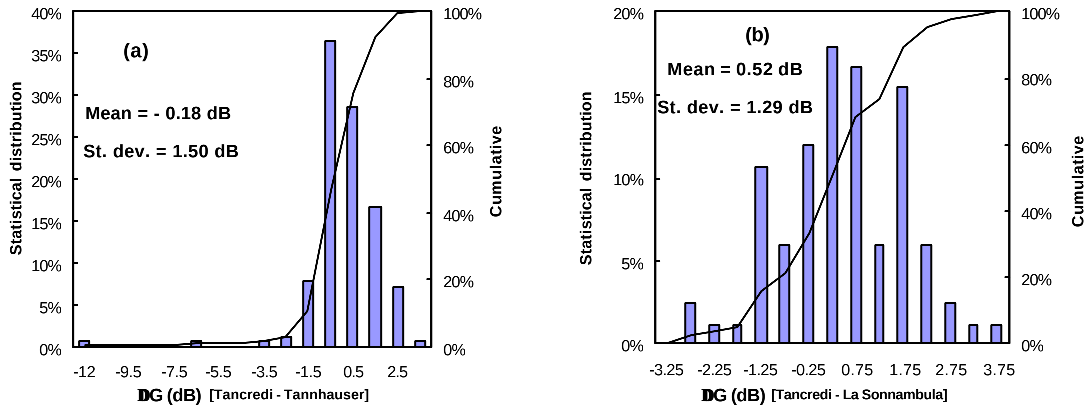

Fig. 7 – Statistical distribution, and cumulative, of the difference for G(f). (a) Tancredi-Tannhauser, (b) Tancredi-La Sonnambula.

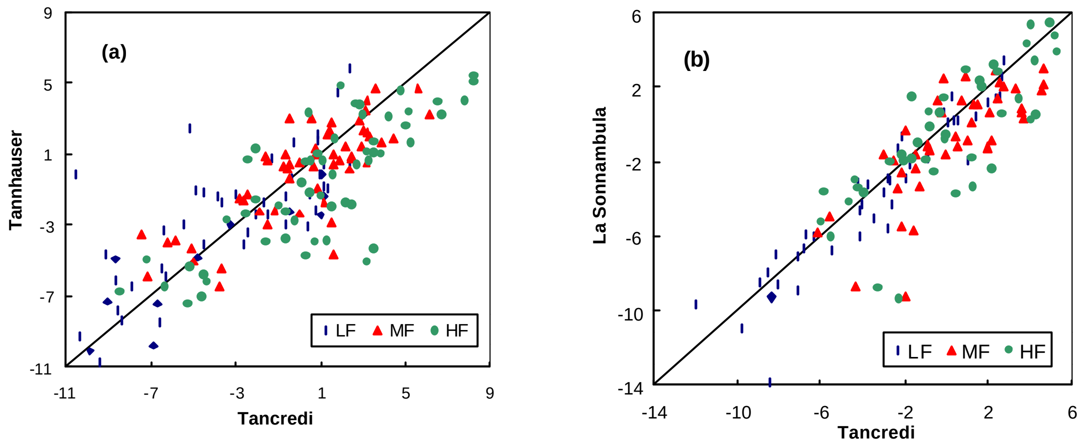

Fig. 8 – Comparison for C_{50}(f). (a) Tannhauser vs. Tancredi, (b) La Sonnambula vs. Tancredi.

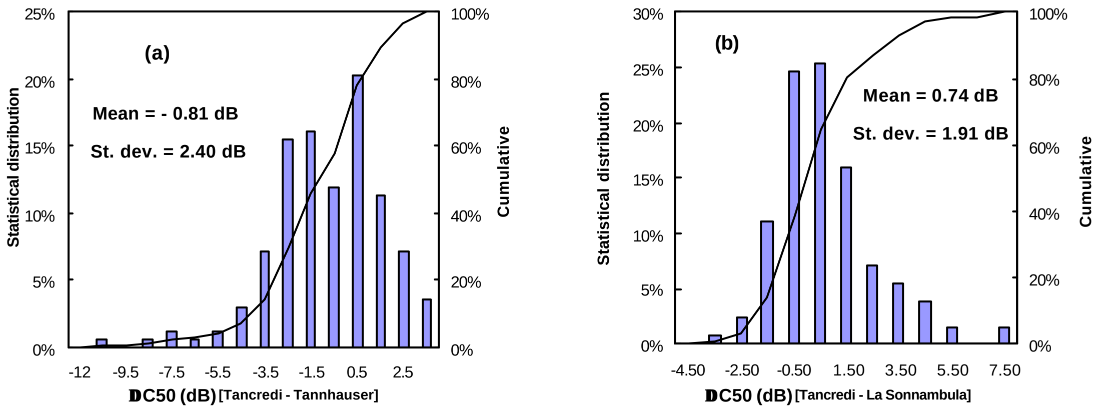

Fig. 9 – Statistical distribution, and cumulative, of the difference for C_{50}(f). (a) Tancredi-Tannhauser, (b) Tancredi-La Sonnambula.

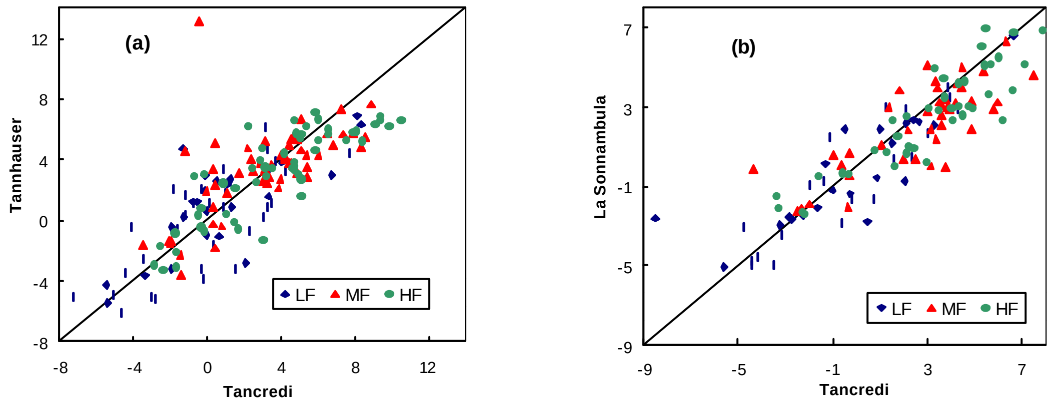

Fig. 10 – Comparison for C_{80}(f). (a) Tannhauser vs. Tancredi, (b) La Sonnambula vs. Tancredi.

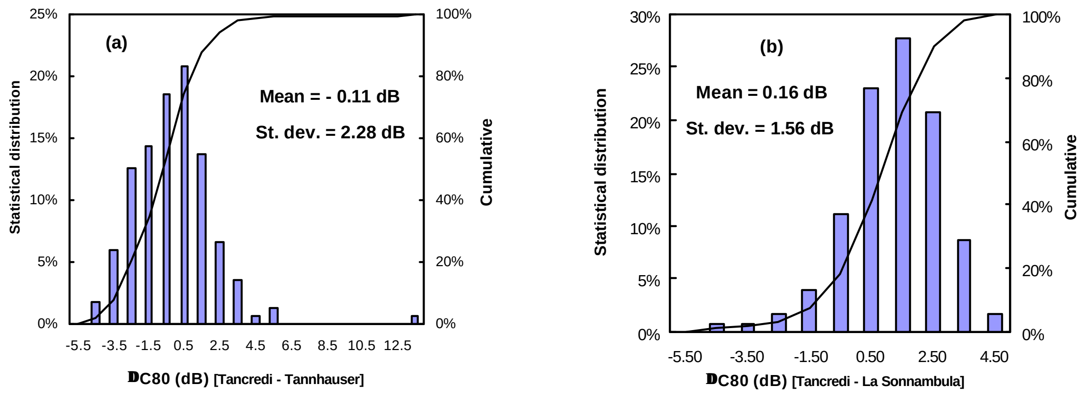

Fig. 11 – Statistical distribution, and cumulative, of the difference for C_{80}(f). (a) Tancredi-Tannhauser, (b) Tancredi-La Sonnambula.

CONCLUSION

The above-reported data do not allow a firm conclusion about the influence of the observed sceneries on the measured objective acoustic parameters. Given a scenery pair and a source-receiver pair and an objective parameter, one finds an increase at one frequency and a decrease at another one. It happens in different ways according to the chosen scenery pair, source-receiver pair and objective parameter. This suggests that only extremely different sceneries that change the acoustic properties of the stage-house markedly would yield differences in the measured parameters that could be related to the change of scenery clearly. The authors are aware of the many shortcomings dependent on time-invariance, signal-to-noise ratio, distortion that may have influenced measurements in the San Carlo in spite of the care taken to assure the repeatability of measurements, save the change of sceneries, as much as possible [4], [5], [6]. Small average differences due to the sceneries, as found significant here for RT, may have been masked by repeatability errors responsible of high values of the standard deviation of the measured parameters.

REFERENCES

[1] Cremer L., Muller H. A., translated by Schultz T. J., *Principles and Applications of Room Acoustics*, Applied Science Publishers, **1**, Barking, Essex, England, 616-617 (1982).

[2] Iannace G., Ianniello C., Maffei L., Romano R., *Objective measurement of the listening condition in the old Italian opera house "Teatro di San Carlo"*, Journal of Sound and Vibration **232** (1), 239-249 (2000).

[3] Rife D. D., *Reference manual MLSSA*, version 10 (1996).

[4] Pelorson X., Vian J. P., Polack J. D., *On the variability of room acoustical parameters: reproducibility and statistical validity,* Applied Acoustics **37**, 175-198 (1992).

[5] Griesinger D., *Beyond MLS - Occupied hall measurement with FFT techniques*, AES Proceedings 4403 (M-3), November 8-11 (1996).

[6] Nielsen J. L. M., Halstead M. M., Marshall H., *On Spatial Variability of Room Acoustics Measures*, Proceedings 16th ICA and 135th ASA Congress, Seattle, 2141-2142 (1998).