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The "Teatro di San Carlo" in Naples and its smaller clone "Teatro Verdi" in Salerno

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The Teatro di San Carlo in Naples (Italy) is a well preserved baroque-type theatre. It was opened in 1737 and flourished up to a destructive fire. Nine months after the disastrous event the San Carlo was rebuilt completely as it was and reopened in 1817. It is still praised for its sound quality for opera performance. The Teatro Verdi was conceived by the Municipality of Salerno (Italy) in 1843. However, the "querelles" of local parties delayed much its construction so that it could be opened only in 1872. The architects who designed the Teatro Verdi were influenced very much by the successful Teatro di San Carlo and tried to copy the older and not-far-one in a smaller scale. The Verdi has undergone few minor changes during its life and is used also for opera shows. The main-hall volumes of the two likes are in a ratio about 5:1. This paper reports a comparison of their acoustical features in terms of objective room-acoustics parameters accepted for opera-house sound quality. Acoustic measurements were performed with the same instrumentation set. Similarities and differences are discussed.

1 Introduction

The Teatro di San Carlo in Naples (Italy) is considered the oldest Baroque-type working theatre in Europe. It was opened on 4th November 1737 under the King Charles of Bourbon who endowed the Capital of the Reign of Two Sicilies with this majestic opera house. The San Carlo flourished until a destructive fire on the 12th February 1816. Almost immediately King Ferdinand of Bourbon ordered its reconstruction as it was according to the plans of architect Giovanni Antonio Medrano. Architect Antonio Niccolini fulfilled the desire of his sovereign and the restored San Carlo was reopened on the 12th January 1817, nine months after the disastrous event. Besides an enlargement of the stage and the introduction of the orchestra pit at the recommendation of Giuseppe Verdi in 1872, the auditorium has undergone no major change. Many famous artists, conductors and artistic managers as well contributed to the good reputation of the theatre. It is still praised for its sound quality especially for opera performance. An artistic history of the San Carlo can be found in ref [1].

The Municipality of Salerno (Italy) decided to build a new theatre in 1843. However, the many "querelles" of local parties about the design, the location of the building, the costs involved and other causes, delayed the construction of the theatre which could be started only in 1864. Finally, the Teatro Municipale was opened in 1872 and renamed Teatro Verdi in 1901. The architect who produced the first design of the new theatre was Gaetano Genovese. From 1836 to 1846 he was engaged in the construction of a wing added to The Royal Palace in Naples which is located close to the Teatro di San Carlo. This circumstance may have influenced the first plan of Genovese. Unfortunately, his drawings are lost. However, conjectures are reported that the auditorium of the new theatre had been conceived as a reduced-scale copy of the older San Carlo. On the 15th December 1863 the Town Council of Salerno approved the resolution to build the "*novello teatro*" and the architect Antonio D'Amora was entrusted with planning. Also his drawings are lost but a detailed technical report to the Mayor of the time Matteo Luciani has survived. It is interesting to report how D'Amora explained one of his choices:"…*as regards the shape of the plan of the theatre, starting from the proportions of the Teatro Massimo di San Carlo in Naples, to avoid the abrupt change of the join between the circular part and the straight parts…a circular arc with a smaller radius was inserted into the joins…".* D'Amora referred to the "*proportion*" of the San Carlo also in other sections of his report [2]. The Verdi displays the feature that the entrance to each box is preceded by a small room. D'Amora justified their presence as spaces both to clear the visible boxes from clothes, chairs and other indecorous items and to reduce the noise of people moving and chatting along the corridors. The true reason of their existence was the need to comply with the criticism of Mayor Luciani who stated that: "…*certain pleasures must be the privilege of a not-large audience…the main hall is too large with respect to the needs of citizens and could not be occupied fully in every case*…". In the original plan designed by D'Amora the main hall was larger and the buffer rooms were the original boxes.

Since its opening this historical theatre has undergone few minor changes during its life. The last restoration was carried out after an earthquake, on the 23th November 1980, that had produced little structural damage. Today the Teatro Verdi serves many purposes including opera performance [3].

This paper reports a comparison of both their architectural and acoustical features in terms of some objective room-acoustics parameters accepted for opera-house sound quality. Similarities and differences are discussed**.**

2 Architectural features

Fig.1 shows the views of the Teatro San Carlo and Teatro Verdi, both toward the stage and from the stage. Some general visual resemblance between the two theatres can be noted. At a first glance also the materials and their usage for decoration and finishing of the in-sight surfaces are similar. Wood, stuccoes, curtains, well upholstered chairs are used lavishly in both theatres. Fig.2 shows the plans and the longitudinal sections of both theatres compared in the same scale.

3 Acoustical features

The objective acoustical characterization of both opera theatres is presented in terms of a first set of room-acoustical parameters (RT, EDT, D_{50} and G) measured with a dodecahedral sound source located on the stage and a second set (RT, EDT, C_{80} and G) measured with the same sound source located in the pit [4]. The first set of objective descriptors may be related to the voice of the singer and the second one may be related to orchestral music [5]. For the sake of brevity results are reported only for receivers located in the stalls. The data for San Carlo refer to 34 source-receiver pairs with source on the stage and 30 source-receiver pairs with the source in the pit. The data for Verdi refer to 24 pairs with the source on the stage and 8

pairs with the source in the pit. The microphone locations at the height of a listener head were distributed almost uniformly in one half of stalls area. It is well known that the acoustical parameters in an opera house depend on the stage setting in a certain degree. The one octave-band reported data are averages for three different settings in the San Carlo and two different settings in the Verdi. Fig.3 shows the comparison of the average values of the considered room-acoustical parameters for the sound source on stage. Thinner lines define ± 1 standard-deviation spans. The analogous information for the sound source in the orchestra pit is displayed in Fig. 4.

Fig.1 – Views of the San Carlo (up) and the Verdi (down); toward the stage (left) and from the stage (right).

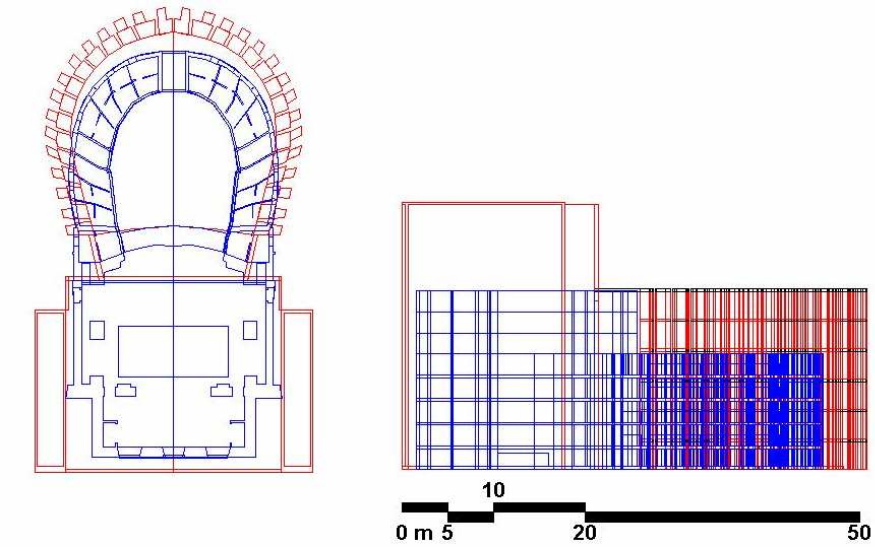

Fig.2 – Sketches of the plan and longitudinal section of the Teatro Verdi (blue) and Teatro di San Carlo (red) in the same scale.

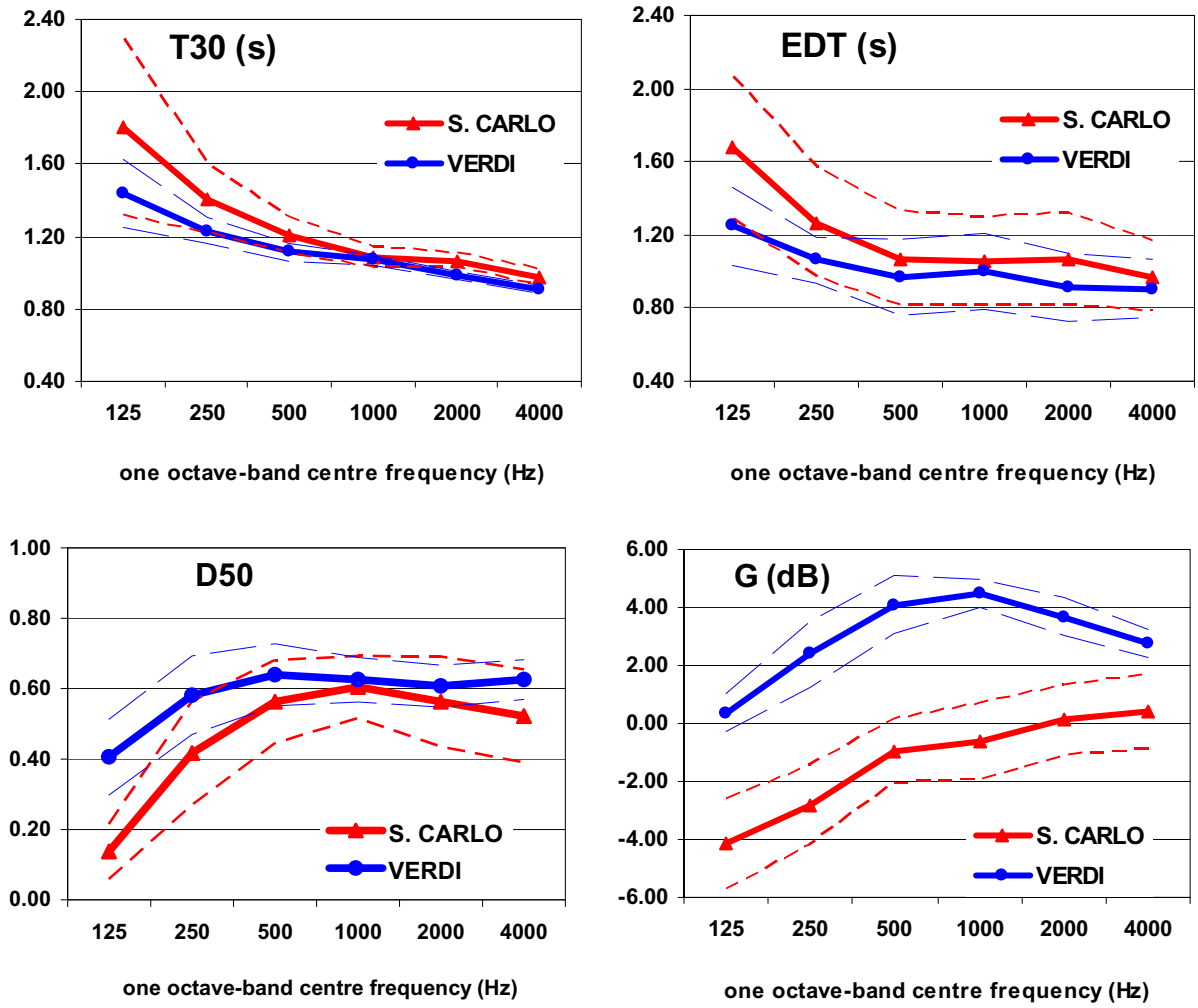

Fig.3 – Comparison of average values of room acoustical parameters in the stalls of the Teatro di San Carlo (red) with those measured in the stalls of Teatro Verdi (blue). Sound source on the stage. Thinner lines define the relevant ± 1 standard deviation span.

The measured objective parameters T_{30} and EDT suggest a lack of reverberance in both theatres. Recent trends favour mid-range values of T_{30} between 1.4 s and 1.6 s in an occupied opera house [6]. However, the reported values are not much different from those measured in other classical opera houses like La Scala (Milan), Opéra Garnier (Paris) or Royal Opera House (London) [7]. The clarity of the voice of the singer on the stage is adequate. Although referring to measurements carried out with a directional sound source on the stage (it approximated the directivity of the human voice roughly), Barron [5] suggested a value D_{50} = 0.5 or higher. The minimum desirable value of C_{80} with the non-directional sound source in the pit was – 2 dB. According to this author the minimum acceptable values for G are 0 dB and – 2 dB measured with the directional source on the stage and the non-directional source in the pit respectively. Probably, the above mentioned criteria are referable to the range of the mid-frequencies. At the end of their study of 23 opera houses Hidaka and Beranek [7] concluded that C_{80}, measured with a dodecahedral sound source on the stage and averaged in the three mid-range octave bands (500 Hz, 1 kHz and 2 kHz), should be between 1 and 3 dB. The same parameter measured with the same sound source in the pit should yield negative values. The value of the mid-range G (average 500 Hz, 1 kHz), measured with the non directional sound source on the stage, should be between 1 dB and 4 dB.

Taking into account the difference between the studies that led Barron and Hidaka and Beranek to the formulation of their tentative criteria, the following brief conclusion can be accepted:

a) the sensation of reverberation is rather poor both in the Verdi and in the San Carlo;

b) the clarity is good in both theatres;

c) the perceived loudness in the Verdi is higher and more satisfying than in the San Carlo;

d) the objective balance [(midrange (G_{stage} – G_{pit})] is about 0 dB in the Verdi and – 0.4 dB in the San Carlo. These values are in the range of the preferable values suggested by Prodi and Velecka [8] and by Barron [5].

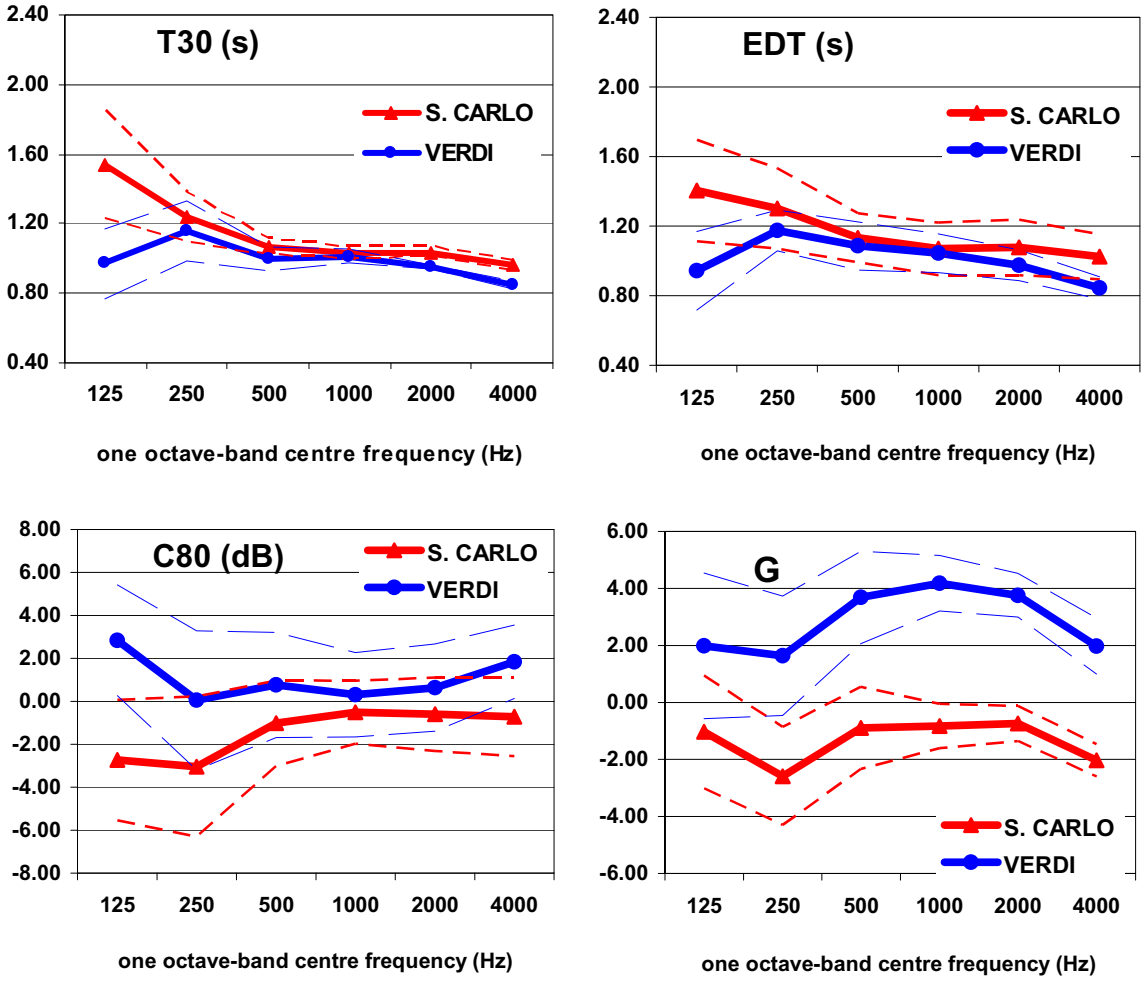

Fig.4 - Comparison of average values of room acoustical parameters in stalls of the Teatro di San Carlo (red) with those measured in the stalls of the Teatro Verdi (blue). Sound source in the orchestra pit. Thinner lines define the relevant ± 1 standard deviation span.

4 Is the Teatro Verdi a reduced-scale model of the Teatro di San Carlo?

Because of the documented history reported briefly in the introductory notes, the authors were stimulated to check if the Verdi presents any objective acoustic character of a reduced-scale model of the San Carlo. It is well known that an acoustic scaled-down model of a hall is appropriate if its geometrical dimensions are a fraction of the full-size counterpart. This allows to carry out measurements inside the model with a reduced scale sound source radiating wavelengths reduced to the scale of the model and transpose the measured responses to the full size hall. The accuracy of the results depends on how well the acoustical properties of the air boundaries, and the air itself as well, at the model wavelength correspond to those of the full size wavelength (see e.g. [9,10]). Obviously, The San Carlo and the Verdi were built both for human dimensions and no perfect geometrical and material scaling had to be expected. Nonetheless it is worth to report the findings of some checks about this issue. Table 1 shows the main dimensions of both theatres and their ratio.

	Length (m)	Max width (m)	Hall height (m)	Stage length (m)	Stage width (m)	Stage height (m)
Teatro Verdi	19.0	14.0	14.0	17.5	15.0	20.0
Teatro di San Carlo	34.0	22.2	24.4	22.0	25.6	28.3
Ratio	0.559	0,631	0.574	0.795	0.586	0.707

Table 1 Approximate dimension of Teatro Verdi and Teatro di San Carlo

An unweighted mean-ratio 0.64 is estimated, that is the average length of San Carlo would be about 1.6 times that of Verdi. A ray tracing in approximated 3D models of the two theatres yielded a ratio of their mean free paths a little higher than 2. On the base of similarity of finishing it was

assumed tentatively that the Verdi might be considered a San Carlo in the scale 1:2. The visual inspection of the measured average values of room-acoustical parameters, T_{30} and EDT in particular, did not reveal any trend suggesting that a 1 octave-band backward shift of the acoustical data of Verdi could overlap those of the San Carlo. To gain a deeper insight into the puzzle a cross correlation between homologous 1/3 octave-band parameter sets, e.g. D_{50} in San Carlo vs. D_{50} in Verdi, and a one way ANOVA as well, were tried. Although some statistical dependence ($p = 0.05$) were found, they were not acceptable with respect to the physical condition related to a scale model.

5 Conclusion

The comparison of the objective acoustics of the considered pair of opera houses in the light of their shape and finishing resemblance showed that the average mid-range T_{30} and EDT are not much dissimilar, both with the sound source on the stage and in the pit. The average mid-range clarity index of the voice D_{50} is a little higher in the Verdi. This happens also for the clarity index of music C_{80} measured with the sound source in the pit. What appears indisputable is the definitely higher sound strength index in the Verdi with respect to San Carlo. Higher G values are linked with higher loudness. G is an important factor contributing to the elusive sensation of intimacy [11]. Finally, the efforts spent in the analysis of data failed in demonstrating that the clone Verdi can be considered a reduced-scale version of the older San Carlo.

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