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The acoustics of the concert hall
Auditorio Juan Victoria from San Juan, Argentina

Ernesto Accolti\textsuperscript{(a,b)}, Yésica Alamino Naranjo\textsuperscript{(b)}, Alción Alonso Frank\textsuperscript{(b)}, Ernesto Kuchen\textsuperscript{(b)}

\textsuperscript{(a)} Instituto de Automática, Universidad Nacional de San Juan UNSJ and National Scientific and Technical Research Council CONICET, San Juan, Argentina, eaccolti@inaut.unsj.edu.ar
\textsuperscript{(b)} Instituto Regional de Planeamiento y Hábitat, Facultad de Arquitectura, Universidad Nacional de San Juan, San Juan, Argentina

Abstract

The Auditorio Juan Victoria is a concert hall located in the homonym cultural building inaugurated in 1970, in San Juan province, Argentina. It seats 976 on an audience area of rectangular plant. The scenario is fan shaped and has the capacity for 80 seated musicians and 90 choristers standing. Hall dimensions are of about 22 m width, 40 m length and 10 m height. The hall is equipped with a pipe organ with 44 ranks and 3 565 pipes. In this article, the acoustic quality of the hall is assessed by a questionnaire. Measurements are taken using the state of the art methods, including ISO 3382-1 parameters. Results are compared with subjective and objective data from other similar halls and recommended values from literature.

Keywords: concert hall, room acoustics, Auditorio Juan Victoria
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1 Introduction

The Auditorio Juan Victoria is a concert hall located in the homonym cultural building inaugurated in 1970, in San Juan province, Argentina. The building contains an outdoor theater, several practice rooms, classrooms, rehearsal rooms, foyers and dressing rooms. Figure 1 shows a general photograph of the building.

Figure 1: Auditorio Juan Victoria cultural building

Figure 2 shows a photograph of the concert hall from the audience area to the scenario. The scenario is fan shaped and has the capacity for 80 seated musicians and 90 standing choristers. Hall dimensions are about 22 m width, 40 m length and 3.50 m to 11 m height. The hall is equipped with a pipe organ with 44 ranks and 3565 pipes.
The ceiling is wooden coffered creating volumes of 150 cm sides and 50 cm depth. Some of these volumes contain luminaries.

The photograph in Figure 3 shows the concert hall from the scenario to the audience area. The hall seats 976 on an audience area of rectangular plant. Sidewalls are wooden with irregularities of about 5 cm depth. A carpet covers the floor and the seats are upholstered in leather.

The hall is small, in volume (9 000 m$^3$) and capacity (976), compared with the concert halls reported in the literature as the halls with the better acoustic quality [1]. Auditorio Juan Victoria concert hall is well known in the regional context for its excellent acoustic quality. Currently it is the oldest of the concert halls especially created only for symphonic music in Argentina. The acoustic consultant was Eng Federico Malvarez.
Figure 3: Concert Hall: Auditorio Juan Victoria. Audience area view from the scenario.

Figure 4 shows a section scheme of the hall. The slope of the audience is 18°.

Figure 4: Concert Hall: Auditorio Juan Victoria. Section scheme (dimensions in m).
2 Measurements

2.1 Monaural measurements

We measure the impulse response with a sound meter microphone and a sound recorder validated for acoustic measurements [2]. We use the method of the integrated impulse response of IRAM 4109-1 [3], corresponding to ISO 3382-1 [4]. Figure 5 shows the plan scheme and the positions of source and microphone.

![Figure 5: Concert Hall: Auditorio Juan Victoria. Plant scheme (dimensions in m). Circles: source positions. Squares: Microphone positions.](image)

We used balloons as impulsive sources (see Figure 3) positioned at the three points marked with circles in Figure 5. We decide to use balloons, although they do not conform the omnidirectional criteria [5] of the standard [3] and [4] in low frequencies because it is a simple technique. We estimated reverberation time, early decay time, and other parameters from ISO 3382-1, from measurements.

We estimated the reverberation time ($T_{30}$) and early decay time (EDT$_{MID}$) using $T_{30}$ and EDT at 500 Hz and 1 000 Hz octave bands with a correlation coefficient of 0.99 (See [3] and [4]). We also estimated the bass ratio from the relation of $T$ at 125 Hz and 250 Hz to $T$ at 500 Hz and 1 000 Hz.

2.2 Sound diffusivity index and initial time delay gap

We estimated the sound diffusivity index using the visual method of weighted average proposed by Haan and Fricke as reported in [1]. We calculated the initial time delay gap $t$ at 24 combinations of source and microphone positions for a sound speed of 343 m/s.
Figure 6 shows one of the time series of the squared pressure that we obtained using a numerical computing software. We used this kind of graphics to review that $t < 20$ ms for each combination source-microphone.

![Figure 6: Impulse response at microphone position 7 for source position 1.](image)

2.3 Sound strength

The sound strength should be measured following recommendations in [3] and [4]. An omnidirectional sound source with known sound power is required. In order to estimate sound strength at mid frequencies $G_{MID}$, in accordance with relations of several concert halls shown in [1], we used

$$G_{MID} \approx 37 - 10 \log_{10} \frac{0.161 T}{V}$$

where $V$: room volume (m$^3$).

2.4 Objective parameters

Table 1 shows a summary of the measured parameters. The early interaural cross correlation for mid frequencies ($IACC_{E3}$) is available from a previous work [6].

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-IACC$_{E3}$</td>
<td>0.66</td>
</tr>
<tr>
<td>$t$ (ms)</td>
<td>$&lt;20$</td>
</tr>
<tr>
<td>$G_{MID}$ (dB)</td>
<td>6.8</td>
</tr>
<tr>
<td>EDT$_{MID}$ (s)</td>
<td>1.7</td>
</tr>
<tr>
<td>BR</td>
<td>0.9</td>
</tr>
<tr>
<td>SDI</td>
<td>0.7</td>
</tr>
<tr>
<td>TR (s)</td>
<td>1.8</td>
</tr>
</tbody>
</table>
3 Questionnaire

We conducted a questionnaire, inspired in the ones introduced by Barron and used by Leo Beranekin [1]. We used a 5-segments Likert scale for each question with categories labels only below the first and last segments. We asked about 1 Clarity, 2 Reverberance, 3 Spatial impression, 4 Intimacy, 5 Sound strength, 6 Balance for: bright, warmth, soloist-orchestra and 7 Background Noise. Finally, we asked by their global impression in 7-segments with the following labels: very poor, poor, almost acceptable, acceptable, good, very good, and excellent.

The translation into Spanish uses Argentine natural vocabulary. The following list shows the translated terms (and labels for segments).

| 1. Claridad musical: | Confuso | Claro |
| 2. Viveza de la sala: | Apagada | Viva |
| 3. Impresión especial | Amplia | Reducida |
| 4. Intimidad acústica | Elevada | Pobre |
| 5. Sonoridad | Elevada | Deficiente |
| 6. Balance |
| I. Altos – Medios | Débiles | Altos |
| II. Bajos – Medios | Débiles | Altos |
| III. Solistas – Orquesta | Débiles | Altos |
| 7. Ruido de fondo: | Inaudible | Aceptable | Tolerable | Intolerable |
| 8. Impresión Global: | Muy mala | Mala | Aceptable | Buena |
| Muy buena | Excelente |

The sample is composed of 25 individuals including 2 directors, 12 musicians and 11 aficionados. Figure 7 shows average responses and the standard deviation. The result for the overall acoustic quality is 92 % with 2 % of standard deviation.

Subjective responses are similar to results reported in the literature for halls with similar acoustic quality. The acoustic quality of the hall is concluded to be between very good and excellent, a difficult condition to reach for such small concert halls used only for symphonic music.
4 Conclusions

We analysed the acoustics of the oldest concert hall designed only for symphonic music in Argentina. There are several older opera houses and theatres in Argentina that are used for symphonic concerts. A remarkable and well-known example is Teatro Colón, which Beranek [1] identifies as one of the best houses not only for opera but also when used for symphonic music.

We measured several objective parameters and conducted a questionnaire collecting subjective responses related to those objective parameters and to the global acoustic impression. The subjective response for global impression is very good to excellent. The global impression relates well with subjective and objective parameters of other rooms with similar global impression.

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