STUDY OF THE ACOUSTIC AND PSYCHOACOUSTIC PARAMETERS IN AUDITION ROOMS. DEPENDENCE WITH DISTANCE

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Abstract

In this study we determined the most representative acoustic and psychoacoustic room parameters. We measured the impulse response in eight rooms with different geometrical and acoustic characteristics at a great number of points (many more than those proposed by the ISO 3382 norm). This made it possible to obtain representations of parameter variations with distance for different rooms. Briefly, one can observe which parameters are characteristic of each room, as well as the existence of common distance dependences between the different rooms.

INTRODUCTION

This study is set within the framework of an ambitious project on room acoustics which is being carried out by four Spanish universities. Here we present the results we obtained in eight auditoriums in the Valencian Community of Spain. The measurement procedure was carried out in accordance with the ISO 3382 norm. We determined the room impulse response (RIR) from these measurements taken at a great number of points distributed throughout the audience areas. We determined the quality parameters required by the ISO 3382 norm and other more recent parameters not included in this norm, using the Winmls software-analyzer 2004. We also analysed the relation between the parameters determined and distance.

The equipment used complies with all the necessary regulations and has been properly calibrated.

STUDIED PARAMETERS

The following parameters were analysed:

- Level parameters: SPL (dBA, sones)
- Energy parameters: G, C50, C80, Tc
- Reverberation parameters: T30, EDT.
- Intelligibility parameters of: STI, RASTI, ALCONS
- Spatial parameters: IACC, LF, LFC.

Level parameters

We have considered the SPL, measured in dBA and sones (Loudness). These levels come from the reproduction of pink noise under the same conditions in each one of the auditoriums. In the following graphs (Figure 1) the dependence of the level parameters with the distance is shown:

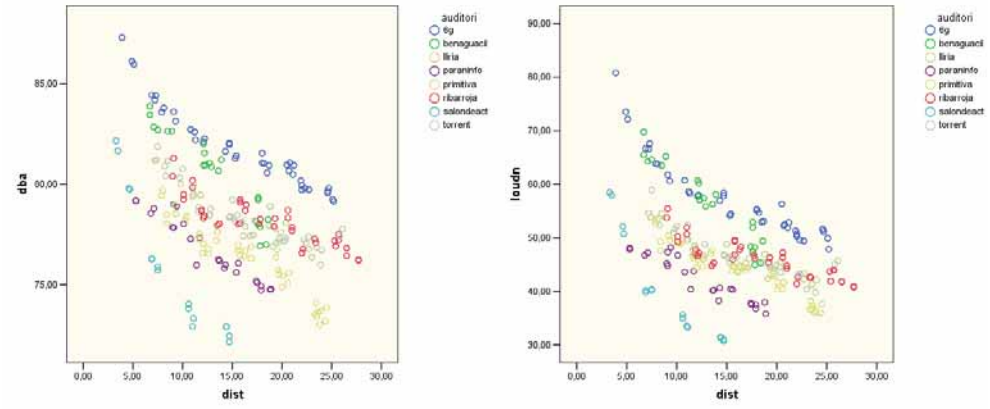


Figure 1 – Level parameters versus distance.

In the following table we present the correlations of the logarithm of the parameters with the logarithm of the distance. ID: Room identifier.

Auditorio	ID	dBA-Dist	Loudness-Dist
Paraninfo (Univ. Politécnica de Valencia, U.P.V.)	1	-0,94	-0,92
Salón de Actos (E.T.S.Ing.Industriales, U.P.V.)	2	-0,99	-0,99
Salón 6G, (U.P.V.)	3	-0,99	-0,98
Auditori de Torrent	4	-0,93	-0,90
Auditori de Ribarroja	5	-0,87	-0,87
Teatre Unió Musical de Lliria	6	-0,94	-0,94
Saló-Teatre de la Banda Primitiva deLliria	7	-0,93	-0,92
Auditori de Benaguasil	8	-0,92	-0,92

Energy parameters

Strength G, Clarity C50, C80, Tc

G, it has been determined by means of the expression:

$$G_{mid} = \frac{1}{2}\left(G^{500\,Hz} + G^{1\,kHz}\right) \tag{1}$$

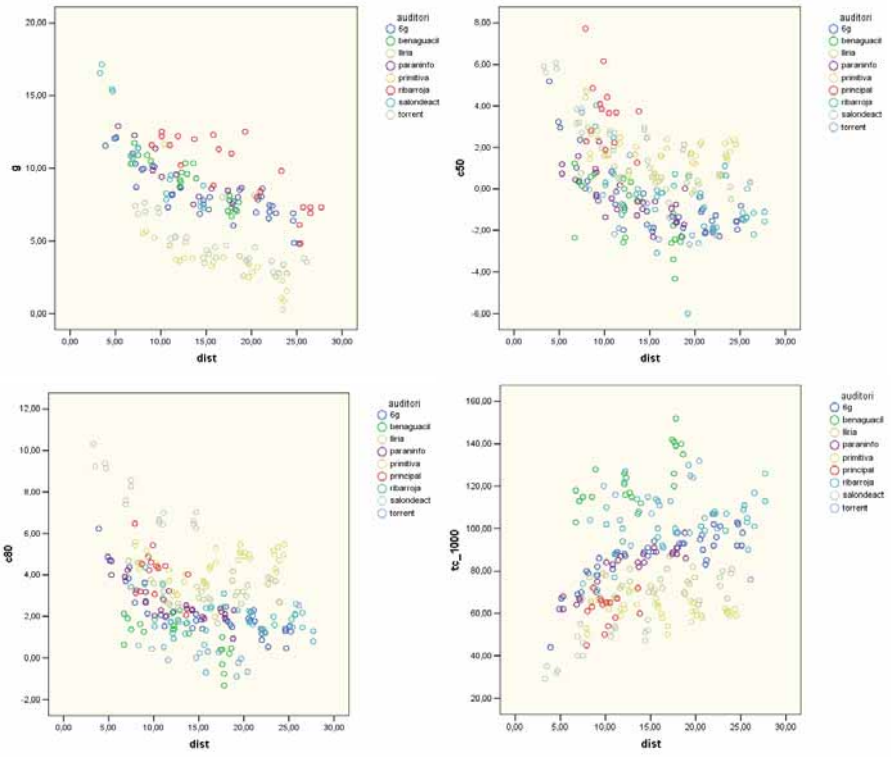
The clarity of the speech C50 and the musical clarity C80 have been calculated by means of:

$$C_{50} = 0.15 \cdot C_{50}^{500\,Hz} + 0.25 \cdot C_{50}^{1\,kHz} + 0.35 \cdot C_{50}^{2\,kHz} + 0.25 \cdot C_{50}^{4\,kHz} \tag{2}$$

$$C_{80} = \frac{1}{3}\left(C_{80}^{500\,Hz} + C_{80}^{1\,kHz} + C_{80}^{2\,kHz}\right) \tag{3}$$

Tc 1 KHz is taken as the reference

In the three first parameters certain decrease is appreciated with the distance. Decrease of G is a common characteristic of the room. . In the case of the Tc, the results show a certain direct relationship with distance, but this does not mean that it can be considered as a parameter that can discern between rooms.



ID	G-Dist	C50-Dist	C80-Dist	Tc Dist
1	-0.85	-0.70	-0.80	0.89
2	-0.91	-0.82	-0.89	0.86
3	-0.84	-0.76	-0.81	0.83
4	-0.86	-0.36	0.12	-0.03
5	-0.84	-0.50	-0.26	0.39
6	-0.62	-0.63	-0.24	0.27
7	-0.74	-0.14	0.32	-0.20
8	-0.92	-0.69	-0.66	0.71

Figure 2 – G, C50, C80 and T_C versus distance and correlation coefficients between parameters and distance (ID: Room identifier)

Reverberation parameters

Starting from the *RIR*, different parameters related with the reverberation are calculated:

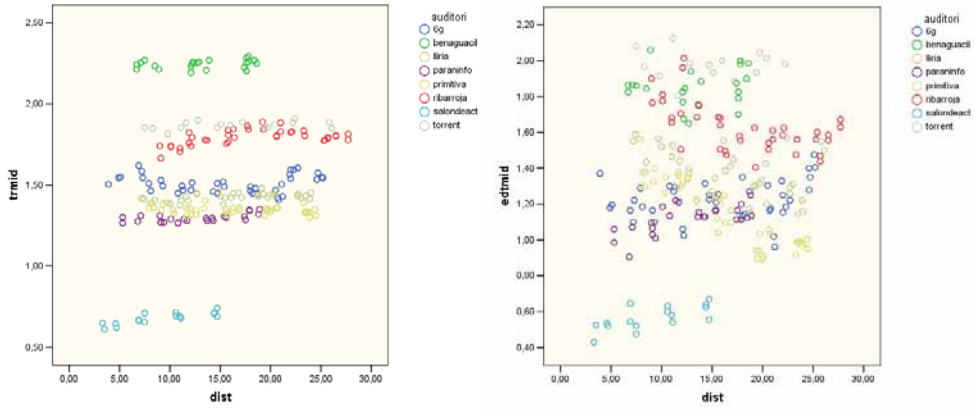
TR mid, EDT mid

TR_{mid} is calculated starting from TR30, by means of the average to medium frequencies

$$TR_{mid} = \frac{1}{2}\left(TR^{500\,Hz} + TR^{1\,kHz}\right) \tag{4}$$

EDT_{mid} is calculated starting from EDT, by means of the average to medium frequencies

$$EDT_{mid} = \frac{1}{2}\left(EDT^{500\,Hz} + EDT^{1\,kHz}\right) \tag{5}$$



ID	TRm	EDTm
1	0.62	0.66
2	0.83	0.69
3	0.02	0.22
4	0.40	-0.64
5	0.49	-0.58
6	0.53	-0.71
7	-0.28	-0.90
8	0.27	0.08

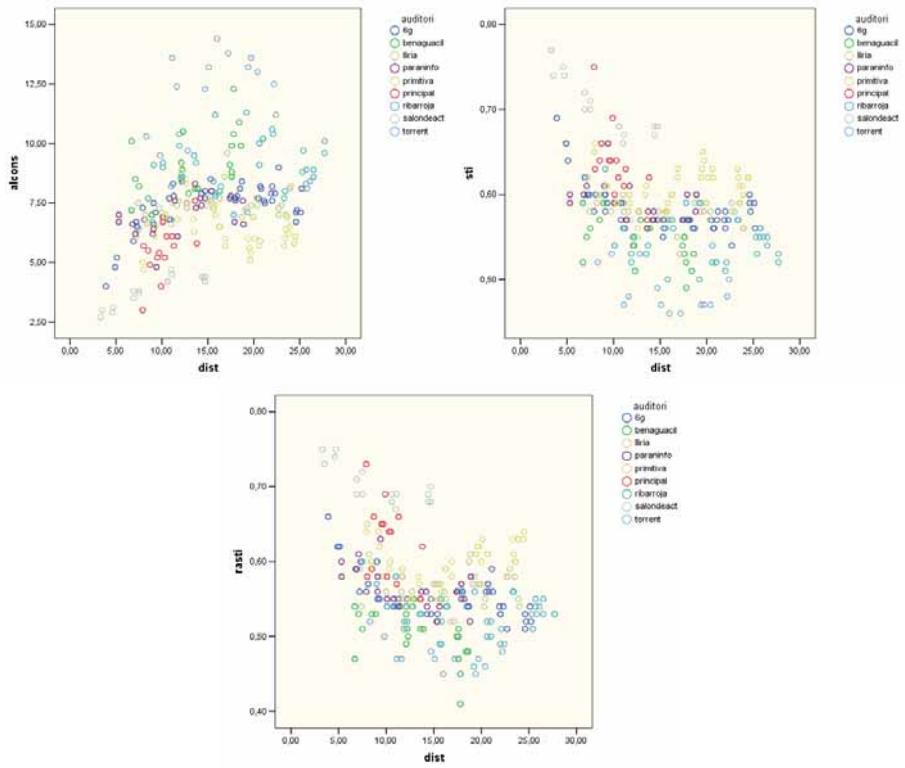
Figure 3 – TR_{mid} and, EDT_{mid} versus distance and correlation coefficients. (ID: Room identifier)

It can be seen that in most of the rooms this parameter is independent of the place measured. This confirms that the TR_{mid}, is a characteristic property of each room. On the other hand, EDT_{mid} is not a room characteristic and it shows a variability with the position but its dependence with the distance it is not clearly established

Intelligibility parameters

STI, RASTI, %Alcons

Although these parameters are related to speech, most of the rooms analysed are "multi-use" theatres and auditoriums, so intelligibility is the basic requirement, therefore we also wanted to present their relationship with the distance.



ID	STI	RASTI	%Alcons
1	-0.48	-0.59	0.53
2	-0.88	-0.79	0.90
3	-0.54	-0.64	0.55
4	-0.12	-0.20	0.08
5	-0.32	-0.20	0.21
6	-0.31	-0.08	0.26
7	0.25	0.31	-0.27
8	-0.52	-0.54	0.55

Figure 4 – STI, RASTI and %Alcons versus distance and correlation coefficients. (ID: Room identifier)

With regard to STI and RASTI, a certain tendency to decrease as the distance increases can be observed, while the Alcons % does not make it possible to appreciate a tendency clearly. The rooms do not show considerably different values for each one of these parameters.

Space parameters

Three parameters were selected that show the dependence on spatial effects.

IACCe

The RIR was measured using a head of HEAD Acoustics. The parameter was determined as follows:

$$IACC_{E3} = \frac{1}{3}\left(IACC_E^{500\,Hz} + IACC_E^{1\,kHz} + IACC_E^{2\,kHz} \right) \qquad (6)$$

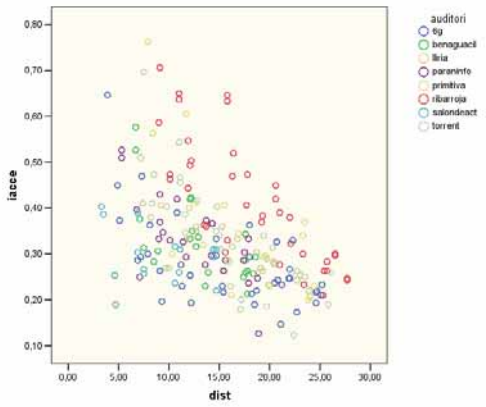


Figure 5 – IACCe versus distance.

Although this parameter has a lot of dispersion at each room it seems to decrease regarding distance (Table 1).

LF and LFC

The definitions used were:

$$\begin{cases} LF_4 = \frac{1}{4}\left(LF^{125\,Hz} + LF^{250\,Hz} + LF^{500\,Hz} + LF^{1\,kHz} \right) \\ LFC_4 = \frac{1}{4}\left(LFC^{125\,Hz} + LFC^{250\,Hz} + LFC^{500\,Hz} + LFC^{1\,kHz} \right) \end{cases} \tag{7}$$

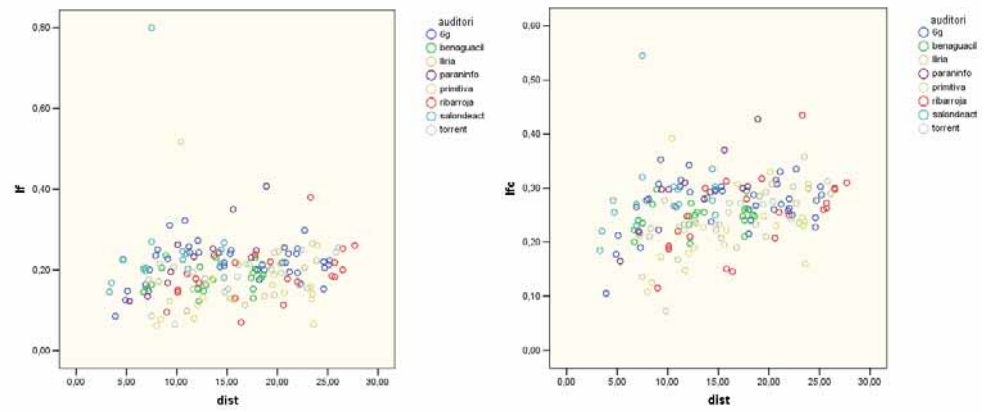


Figure 6 – LF and LFC versus distance.

These graphs show that the LFC is more disperse that the LF. The tendency is to increase with distance, although only very slightly (Table 1)

Table 1 – Correlation coefficients between IACCe LF and LFC versus distance. (ID: Room identifier)

ID	IACCe	LF	LFC
1	-0.72	0.80	0.81
2	-0.26	-0.01	0.19
3	-0.60	0.17	0.31
4	-0.80	0.66	0.77
5	-0.79	0.46	0.57
6	-0.72	0.38	0.56
7	-0.71	0.03	0.39
8	-0.65	0.07	0.21

CONCLUSIONS

From the results we can tell that there are:

1. Parameters that are characteristic of the rooms: TR_{mid}
2. Parameters that decrease with the distance: *G, SPL levels, STI, RASTI, C50, C80, , IACCe.*
3. Parameters that increase with the distance: *Tc, LF, LFC*
4. Parameters that do not present a clear tendency: EDT_{mid}, *%Alcons*

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