CORRELATIONS BETWEEN ROOM ACOUSTIC PARAMETERS

S. Cerda[1], A. Giménez[1]; J. Romero[1]; R. Cibrian[2]; J.L.Miralles[3] J. Segura[4]; J. Navasquillo[4] , R. Lacatis[5]

[1] Grup d´Acustica Arquitectònica, Ambiental i Industrial. Universidad Politécnica de Valencia, Camino de Vera s/n, 46022 Valencia. agimenez@fis.upv.es
[2] Facultad de Medicina. Univ. Valencia. Blasco Ibáñez 15, 46010-Valencia, Rosa.M.Cibrian@uv.es
[3] Facultad de Psicología. Univ. Valencia. Blasco Ibáñez, 21, 46010-Valencia, mirallel@uv.es
[4] Facultad Físicas. U. Valencia, Doctor Moliner s/n, Burjassot, Jaume.Segura@uv.es; Joaquin.Navasquillo@uv.es
[5] Becario MAE-AECI. rala1@doctor.upv.es

Abstract

In this study we determined the most representative acoustic and psychoacoustic room parameters. We measured the impulse response in eight halls with different geometrical and acoustic characteristics at a great number of points (many more than those proposed by the ISO 3382 norm). We determined the following parameters: T30, EDT, Tc, STI, RASTI, AlCONS, SPL (dB, dBA, sones), C80, C50, IACC, LF, LFC. Thus we were able to obtain the correlations between the parameters. These correlations have been obtained taking into account the data of all the halls.

INTRODUCTION

This work 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.

PARAMETERS ANALYSED

The following parameters were analysed:

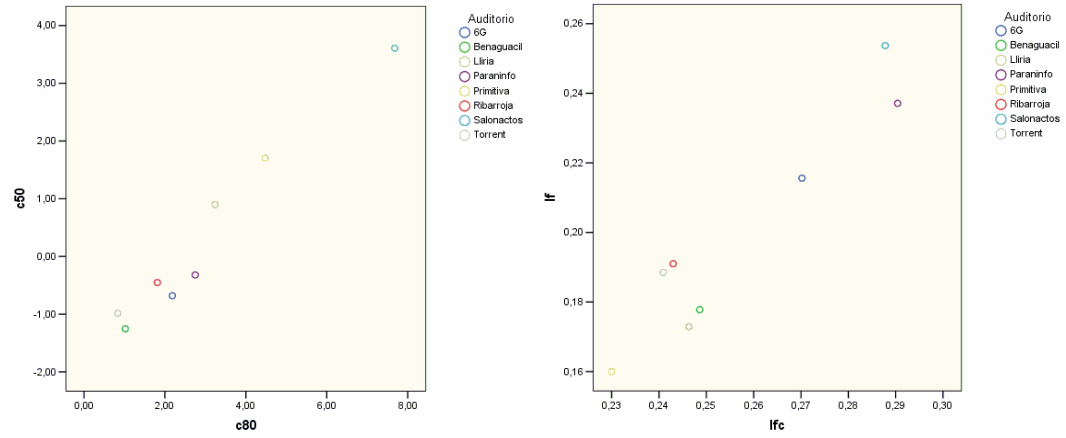
- Level parameters: SPL (dBA, sones)
- Energy parameters: G, C80, C50, Tc.
- Reverberation parameters: T30, EDT.
- Intelligibility parameters: STI, RASTI, AlCONS
- Spatial parameters: IACC, LF, LFC.

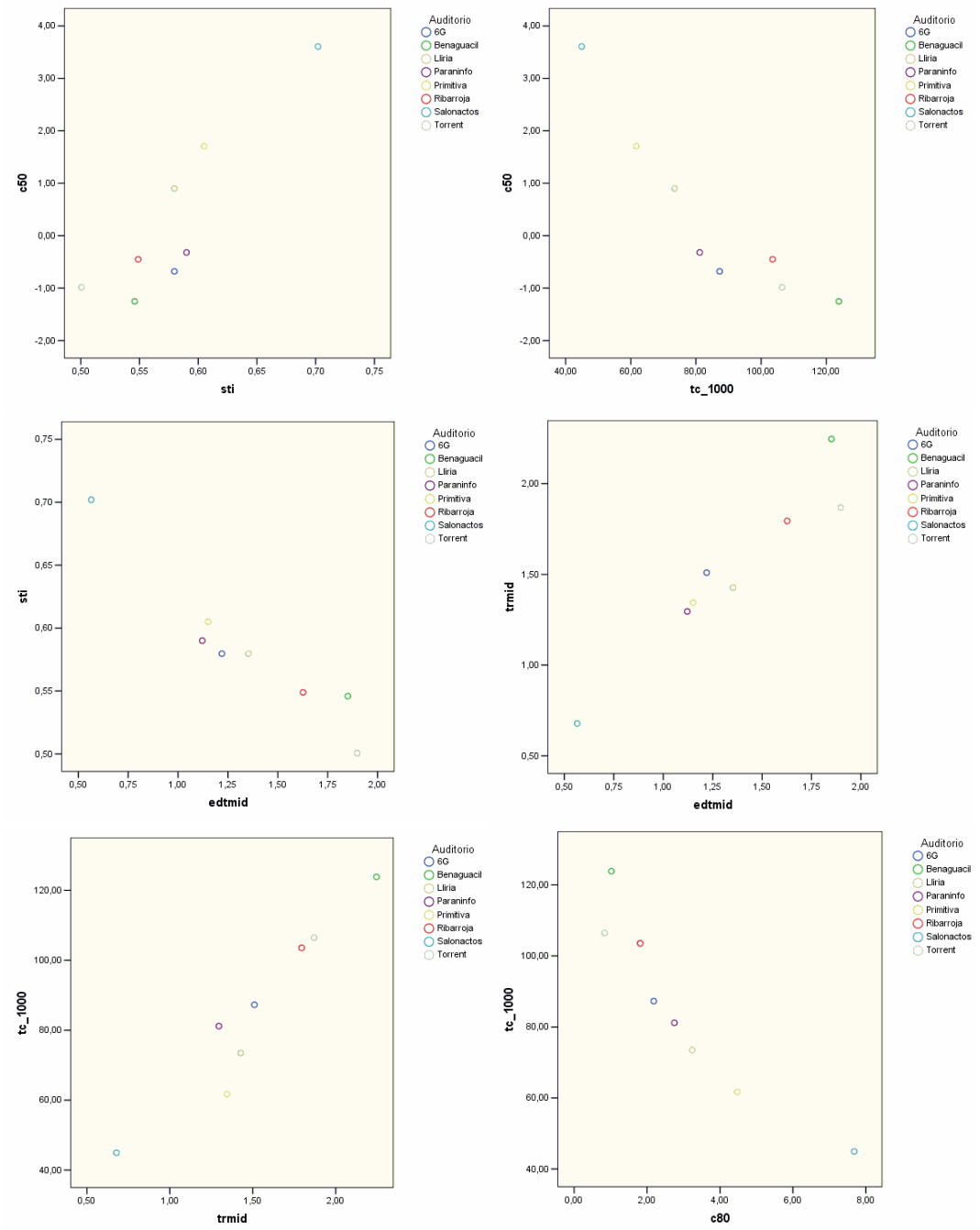
Means correlation

In this section we calculate the means of each one of the parameters analysed in each hall. In the table below we present the correlations we found between these means:

	LF	LFC	G	C50	TC 1000	C80	BRILLO	TR_{MID}	EDT_{MID}	STI
LFC	0,95									
G	0,74	0,71								
TC 1000				-0,92						
C80				0,98	-0,92					
WARMTH	-0,71	-0,77	-0,85							
SHINE	0,85	0,72		0,69		0,78				
TR_{MID}				-0,87	0,96	-0,92	-0,79			
EDT_{MID}				-0,84	0,92	-0,92	-0,76	0,96		
STI				0,90	-0,87	0,96	0,77	-0,89	-0,96	
RASTI				0,82		0,76				0,66
ALCONS				-0,84	0,86	-0,91		0,86	0,95	-0,98

The following figures show the graphs corresponding to the parameter couples with the most relevant correlation coefficients.



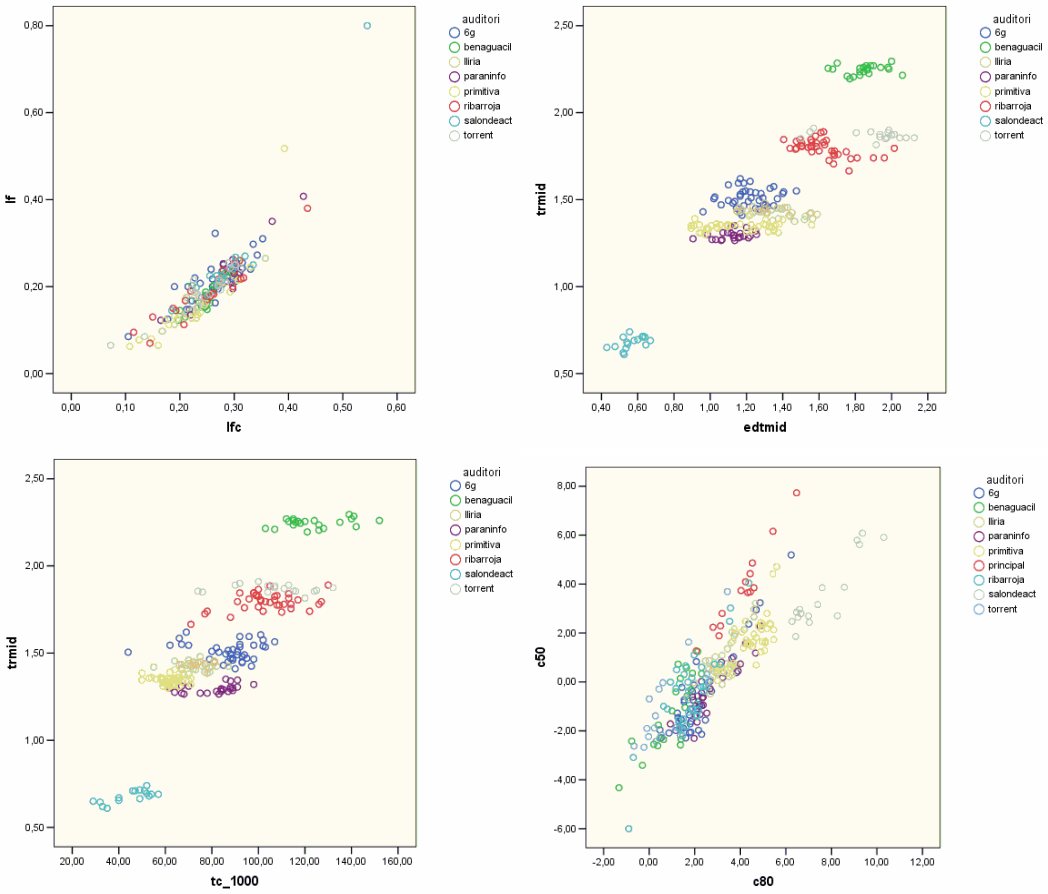


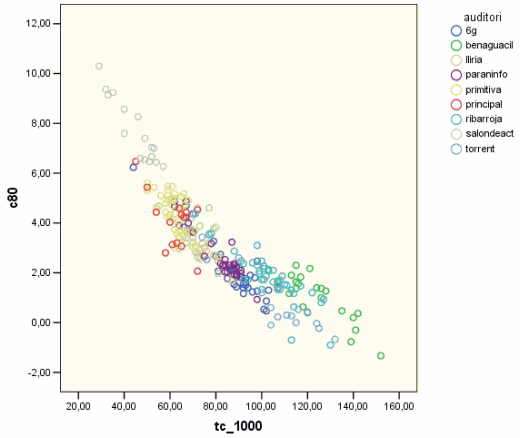
Another interpretation of r-Pearson of interest in this case is the value of r^2, which is the variation percentage of a variable that is explained by the variation of the other variable. This interpretation means, for example, that 96% of C80 variation is explained by a C50 variation. With this consideration some of the parameters usually measured in the halls will be redundant or they give the same information.

Overall correlations

The overall correlations we refer to are those obtained taking all the measurements obtained into account (at each point of each hall).

	lf	lfc	trmid	edtmid	c50	tc_1000
lfc	0,88					
edtmid			0,88			
tc_1000			0,85	0,79	-0,81	
c80			-0,78	-0,76	0,89	-0,90





These correlations are of great interest as they make it possible to establish which parameters can be termed as equivalents or redundants.

Hall correlations

Hall correlations are those that were obtained between parameters determined in each specific hall. Some of the overall correlations were also obtained in each of the halls. This makes it possible to state that the correlated parameters are, in some ways, equivalent. This occurs in the following parameters:

Auditorium	LF-LFC	C50-C80	C80-T_{C1000}
Paraninfo (Polytechnic Univ. of Valencia, U.P.V.)	0.95	0.90	-0.93
Assembly Hall (E.T.S.Ing.Industriales, U.P.V.)	0.95	0.91	-0.94
6G Hall, (U.P.V.)	0.78	0.90	-0.94
Torrent Auditorium	0.93	0.79	-0.92
Ribarroja Auditorium	0.94	0.82	-0.87
Lliria Music Association Theatre	0.95	0.82	-0.51
Lliria “Banda Primitiva” Theatre Hall	0.88	0.72	-0.58
Benaguasil Auditorium	0.85	0.82	-0.84

Very clear correlations in several halls can be seen in some cases although some specific halls break the correlation. Perhaps this is related with the hall geometry.

Also it must be noted that some overall correlations are broken in one particular hall, for example TR_{mid}-EDT_{mid}, TR_{mid}-T_{C_1000}. These correlations work between mean values and taking all the halls together. If we observe the previous graphs, we can see that TR_{mid} and EDT_{mid} are very characteristic parameters of each hall.

Finally, some correlations appear between parameters in only some of the halls. At present, we do not consider this to be important.

CONCLUSIONS

Three types of correlations are considered:

- Correlations between means. Of particular interest: LF-LFC, C50-C80, TR_{mid}-$T_{C\ 1000}$, C80-STI, TR_{mid}-EDT_{mid}, EDT_{mid}-STI, EDT_{mid}-AlCONS, STI-ALCONS.
- Overall correlations. Of particular interest: LF-LFC, TR_{mid}-$EDT_{mid,}$ TR_{mid}-$T_{C\_1000,}$ C50-C80, T_{C_1000}-C80.
- Correlations in each hall: LF-LFC, C50-C80, T_{C_1000}-C80.
- The parameters, LF-LFC, C50-C80, T_{C_1000}-C80, that they have high correlation coefficients in all studied situations, can be consider as equivalents.

REFERENCES

[1] Research project “Establishment of determining acoustic parameters of the quality perceived in concert halls and auditoriums. Proposal for their application in projects of new construction or restoration” BIA2003-09306-C04, Plan Nacional de I+D

[2] Winmls 2004 (Morset Sound Development)

[3] Handbook for Sound Engineers, Third Edition Glen M. Ballou, editorial Springer-Verlag; 2nd edition (November 3, 2003)- 0387955240

[4] Auditorium Acoustics and Architectural Design, Michael Barron, editorial Spon Pr; (March 1, 1993)- 0419177108

[5] Zwiker, E and Fastl, H. “Psychoacoustics. Facts and Models”. Springer Verlag. 1990

[6] Giménez, A.; Marín, A.; Sanchis, J. Romero, Subjective Parameters of musical Rooms. Auditorium conference. Auditorium design at the millennium. Institute of acoustics OF U.K, Belfast. 1997. ISBN 1901656004.

[7] S. Cerda; A. Giménez; J. Romero; J. Navasquillo; R. Cibrian; R. Lacatis; J.L.Miralles ; J.V. Garrigues.; P.E.Giménez; A. Sanchis; A. Marín; C. Dema. “Uso de los parámetros psicoacústicos como herramienta de análisis en acústica de salas”

ACKNOWLEDGEMENTS

This study was subsidized by the FEDER and the Ministry of Education and Science in the Plan Nacional I+D within the coordinated research project, reference BIA2003-09306-C04.

We thank the Polytechnic University of Valencia, the Technical School of Industrial Engineers, and the auditoriums and theatres in the Valencian Community that are mentioned in this study, for their constant support in letting us use their halls in order to carry out our study.