Proceedings of the Institute of Acoustics

COMPARISON BETWEEN THE RESULTS OF OBJECTIVE AND SUBJECTIVE SURVEYS IN A DUAL-PURPOSE HALL

C Sémidor

Ecole d'Architecture et de Paysage de Bordeaux, ERIAC (Equipe de Recherche Interdisciplinaire sur l'Acoustique et le Confort en architecture et urbanisme), France

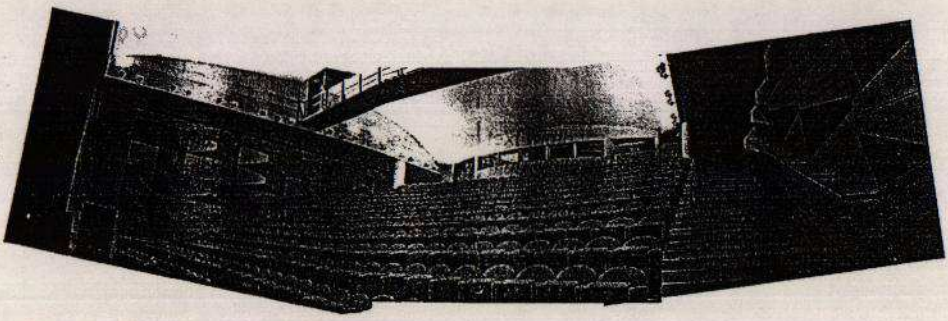
1. INTRODUCTION

Like some authors [1], our research team proposes a global approach of the listening comfort, that takes into account both the physics phenomena (through measurements, simulations and predictions), the human aspect (through opinions of auditors and performers) and the spatial properties (through the architecture of the hall).

This paper deals more particularly with the relationships between objective and subjective results of an acoustic survey in a dual-purpose hall. In each case we proceed in 2 steps: first acoustic measurements and then investigations with ordinary concert or theatre-goers.

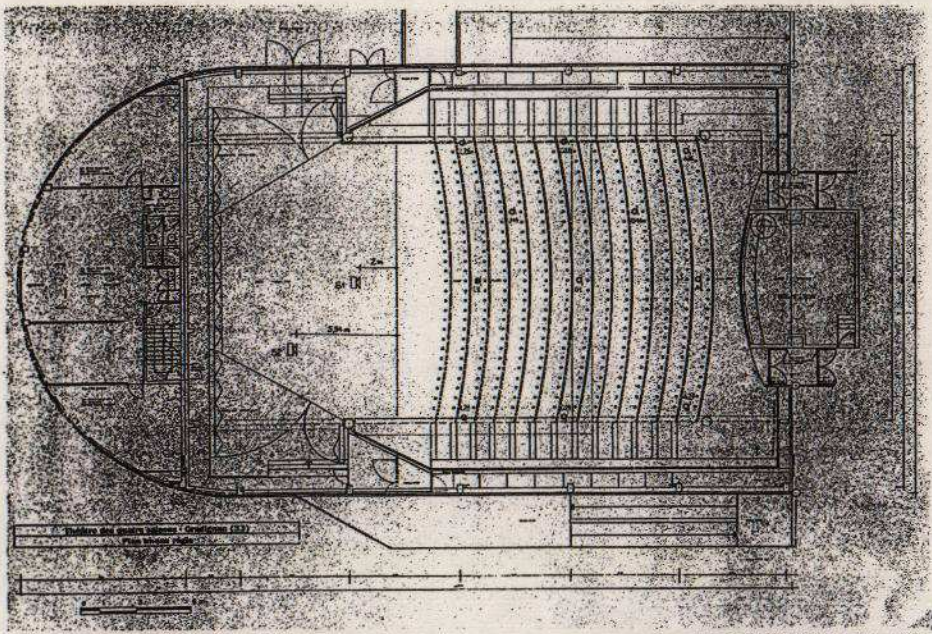
2. THE CHOICE OF THE HALL

The hall selected for the first experiences is the "Four Seasons Theatre"; it is situated at Gradignan, (Bordeaux suburbs) and was built in 1989-1990 by Mrs Gonfreville and MM Arsène-Henry, Triaud, architects with Commins bbm as acoustic consultant and MM François, Manoury, Guignard as scenographs. This hall has a capacity of 400 seats, the audience area is 405 m^2 and it can be used with an adaptable stage: one arrangement for the theatre, another one for chamber music concerts.

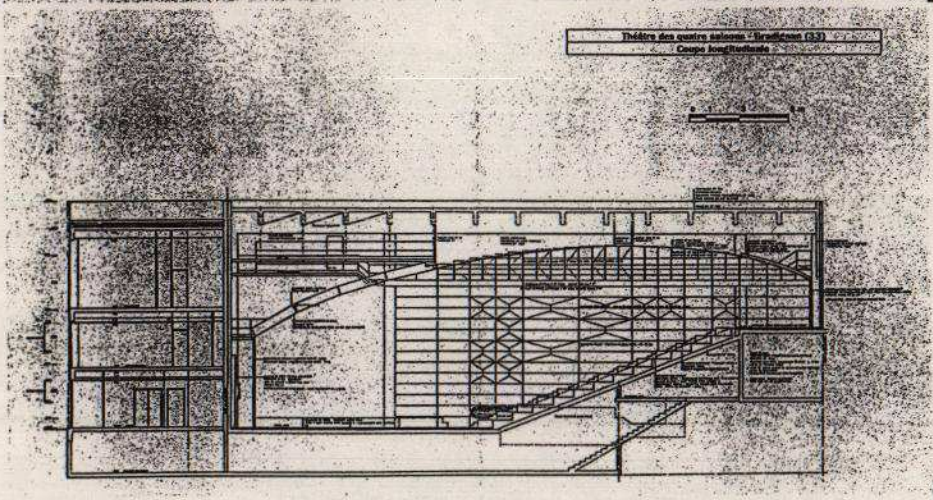


Picture 1 -The interior from the stage end.

OBJECTIVE AND SUBJECTIVE SURVEYS IN A DUAL-PURPOSE HALL



2

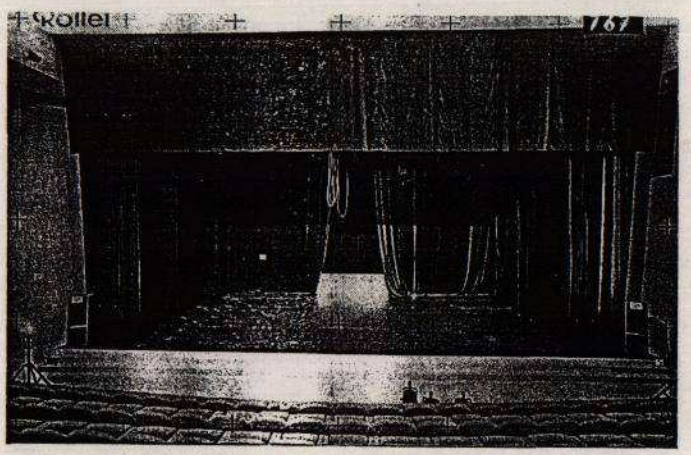


3

Pictures 2 and 3 display a plan and the long section; the source and the measurement positions are located on the plan. The seating area includes 14 rows of highly sound-absorbing upholstered chairs, following a steep rake which allows a very good visibility and a poor grazing incidence effect. The walls on each side are made of wood with large four-sided wooden pyramids to scatter the sound, the rear wall is in wooden perforated panels hiding 50 mm of glass wool; the 22 mm wooden floor is built over a 70 mm empty space and the ceiling is made of thick ply-wood panels (40 mm). The colour of the wood is very clear, which causes some problems during the performances because of the reflection of the spotlights.

2.1 Theatre arrangement

In this case the area of the stage is about 210 m^2 and it is separated from the backstage by a thick velour curtain. So the total cubic volume - which includes a small flytower with a "false" grid to support painted canvas and a lighting system - is 5,400m^3; this gives almost 14 m^3 per seat. Proscenium opening : width 16 m, height 8 m.



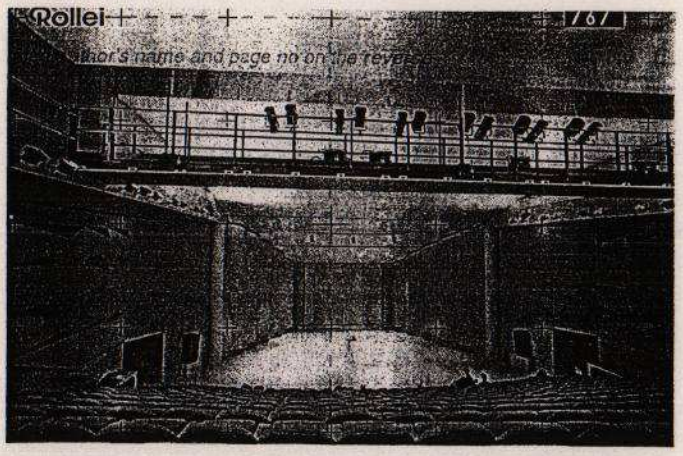
Picture 4

2.2 Chamber music arrangement

A technical system is required to convert the platform of the stage into a wooden canopy; moving wooden walls with four-sided wooden pyramids close the orchestra shell. Then the stage surface is at the same level than the ground floor and offers an area of 418 m^2.

The total volume is of 3,900 cubic meters which gives ~9.7 m^3 per seat. The technical bridge can be retracted, but often remains unsealed during the performances.

OBJECTIVE AND SUBJECTIVE SURVEYS IN A DUAL-PURPOSE HALL



Picture 5

The different reasons that lead to the choice of this specific hall to achieve our study, that is to elaborate a questionnaire understandable by ordinary listeners, are listed below:

- an easy organisation for testing two types of performance due to the two stage configurations,
- a relatively small capacity which enables us to bring enough people together to answer to the questionnaire in a statistically valid experience,
- a seating area absorption which is the same with or without audience,
- an acoustics without problems which prevents the audience attention to be disturbed by focusing it on the defects of the hall acoustics.

3. THE OBJECTIVE MEASUREMENTS

3.1 The methods

The measures have been made with two complementary methods provided by the 0.1dB company. The first one, called dBImpuls, is based on the average MLS correlation technique to obtain the impulse response to access to usual objective criteria (Reverberation Time TR60 [s] measured between -5 dB and -35 dB, Early Decay Time [s], objective Clarity 80 [dB], Definition 50 [%], Speech Transmission Index, RApid Speech Transmission Index); the second one, called dBBati, is based on pinked interrupted noise recording technique which allows to estimate TR60, EDT and the sound pressure level distribution; this one is less restrained by the influence of a relative high background noise level.

For the two methods the same loudspeaker is used to diffuse the source signal.The twelve receiver positions are uniformly distributed upon the audience area and the measures are made for 2 positions of the source, each one becoming the receiver position for the other. All measurements have been made in an unoccupied hall.

3.2 The results

Concerning the objective sound level distribution, we can note that it is homogeneous enough all over the audience area since the difference between the farthest position and the nearest one from the front stage is less than 7 dB(A) for the two stage arrangements. The background noise level is about 30 dB(A), corresponding to NR 25.

In the theatre configuration stage, the value of C80 is around 7 dB at 1000 Hz, D50 75%, STI and RASTI 0.75 whatever the source position may be. In the music configuration stage C80 varies from 4 to 5 dB, D50 from 50% to 60%, STI and RASTI nearly 0.6.

For the two arrangements, we present below the comparative curves of the average values of TR60 and likewise the average values of EDT, which are almost constant over the whole audience area because of a good diffused sound field.

3.2.1 Theatre arrangement We can see that TR60 and EDT curves are close for the two source positions, which proves that this parameter has no influence; this is due to the restricted size of the stage and the presence of a lot of velour curtains.

The values are greater when they are obtained with dBBati method, but for TR60 they are always smaller than the recommended values for this use and this cubic volume.

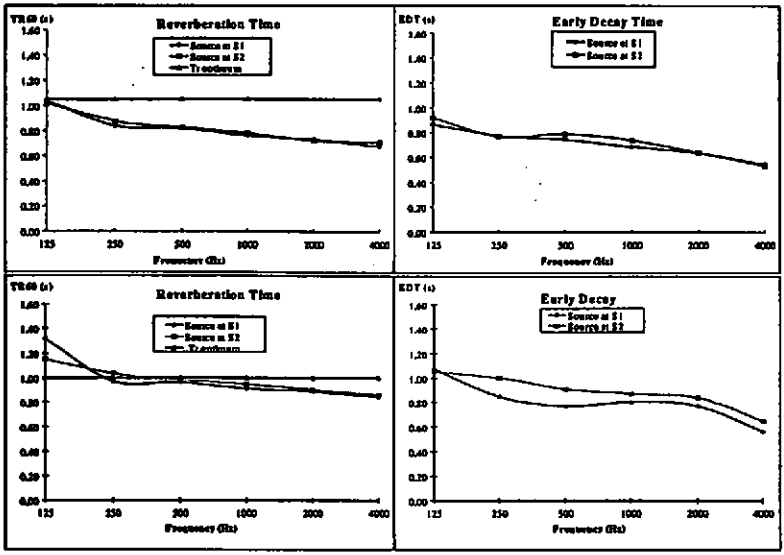
As the values of C80, D50, STI and RASTI show and as the sound level distribution do, these remarks confirm that there is a good sound diffusion by the lateral walls and a little too much absorption by the seating area and the scene curtains.

3.2.2 Chamber music arrangement The curves below still show a poor influence of the source position due to the presence of the four-sided wooden pyramids on the orchestra shell. The results from dBBati are always upper than those from dBImpuls which is quite due to the method. But except for the values at 125 Hz, the curve fits well with the recommended values.

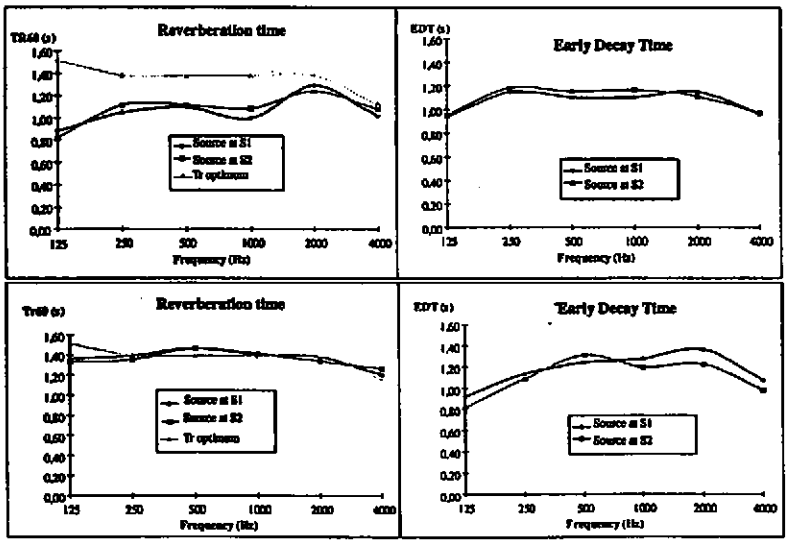
All the above criteria show a difference of acoustic quality between the two stage arrangements; this validates the choice of this hall for testing our questionnaire for ordinary listeners.

OBJECTIVE AND SUBJECTIVE SURVEYS IN A DUAL-PURPOSE HALL

Theatre arrangement - Measurements with dBImpuls then with dBBati



Chamber music arrangement - Measurements with dBBati then with dBImpuls



4. SUBJECTIVE SURVEY

4.1 Elaboration of the questionnaire

In hall acoustics studies, few subjective surveys have been conducted with ordinary concert- or theatergoers. Usually subjective criteria studies are carried out with "professionals of sound" in the audience area or on the stage [2], [3], [4]. Even if the subjects are not expert, the vocabulary used is commonly the same as the one utilised by expert listeners. The results of a first experience conducted before [5], have shown that these technical words are generally misunderstood. Therefore we propose a method to build a set of questions about the way that auditors judge what they listen to; the goal is to put simple words in place of the specific language in order to describe their sensations.

To find a vocabulary easy of access for every one, we have organised interviews with volunteers to clarify the relationships between the hearing impressions and the specific words. Two groups of 6 and 7 people have participated to the establishment of these links following two processes: a list of words has been given to one group before the interview, the other group arriving without any preparation.

After these interviews, we have prepared a questionnaire using periphrases to query the listener and to allow him to express his sensations. This questionnaire is composed of six parts, containing about thirty questions, most of them admitting a single answer among four possibilities. The treated themes are:

- The listener and the arts: uses and relations with performances.
- During the performance: needs and expectations with respect to comfort.
- Concerning the performance: comparative descriptors allowing the neutralisation of the performance effect.
- Concerning the room: evaluation of social and physical comfort.
- The hall and the sound: evaluation of acoustical comfort.
- Condition: classical descriptors.

Three versions of the questionnaire has been written: concert, opera, theatre. In order to test the validity of this model, we have organised twice the same live performance with professional musicians, singers and actors in the hall described above.

The musical formations (solo, trio, quartet, quintet) who have played are typical of the entertainment performed in this hall [6].

4.2 The results

These investigations were conducted with 47 subjects for the music configuration and 49 subjects for the theatre configuration; 39 of them have taken part in the two experiences. The population was constituted by 49% males for both tests. The audience was well distributed on the seating area and no row remained unoccupied.

Concerning the general comfort appreciation for a theatre, an opera house or a concert hall, the physical aspects (acoustics, visibility, temperature, space around a seat,...) seem to be more important than the aesthetic ones (colour, form, size,...). But the most important is a good interpretation of the performers in order to make the listeners appreciate the show.

We can not present here in details all the answers concerning the acoustical comfort preference for each type of performance hall, but we must note that all the propositions of hearing sensation descriptors to have a "good" hall seem to be equally important. There are 13 items for a concert hall, 16 items for an opera house and 11 items for a theatre. The only point where the answers differ in opinion is about the preference of being surrounded by the sound; 53% people questioned during the music configuration experience and 49% of them for the theatre configuration test have this preference. These results are similar to those obtained with expert listeners.

Concerning the judgement upon this hall the results show clearly that it is well estimated by the audience (well lighted, clean, pleasing to eye, quiet,...). They have also a favourable opinion about the technical aspects: no inconvenience due to external or equipment noises, good sightline,....

With regard to the acoustic qualities the question about the sensation of envelopment by the sound obtains different answers. In music configuration people are more (80%) to perceive the sound coming directly from the stage. In theatre arrangement they are 62% only feeling the same sensation.

The reverberance impression is greater for the music arrangement than for the theatre one particularly at high frequencies and the loudness is judged adequate for the two configurations.

For the other hearing impressions the answers are very close whatever the configuration may be. As an example are given on the table below (1) the following answers rates from "enough" to "very well" for the question:

"During the performance have you the sensation of well hearing ?":

1

Qualities	Music configuration	Theatre configuration
Musicians ensemble execution	100	94
Soloist execution	98	96
Balance between the different instruments	87	83.5
Gradations in musicians execution	89	92
Song and music accompaniment	92	85,5
Singer anywhere on the stage	96	98
Actors' voice	81	-
Gradations in actors execution	80.5	-
Sound transmission from the stage to the audience area	93.5	92
Sounds stronger than another ones	57.5	45.5
Frequencies balance	78.5	65.5
Echo impression	21	6
Clean sound attack	93.5	92
Forced actors' voice sensation	13	-
Balance between the musicians and the singer	74	85.5

The impression of very clean sound attack is due to the relatively weak value of EDT. All these impressions can be well connected to the objective criteria determined above. The percentage values show that this hall presents a good acoustics for the audience who thinks that the sound is distinct (94% - 80%), natural (83% - 80%) and close (74.5% - 77.5%).

The next table (2) gives the percentage of positive answers to the question "Is this hall configuration well adapted to the following type of performance ?":

2

Type of performance	Music configuration	Theatre configuration
Concert	85	67.5
Song	89.5	67.5
Theatre	55.5	-

The none answer concerning the theatre configuration is explained by the lack of actors for this experience.

5. CONCLUSION

The goal of this study was to find a methodology to elaborate a questionnaire destined to ordinary listeners. The choice of the hall in which the experiences had to be conducted was based on general and acoustic comfort criteria.

The objective measurements carried out in the selected hall show that the classical objective criteria are in respect with the recommended values. We could conclude that the acoustics of each hall configuration is good enough not to disturb a test population. We had to confirm that the terminology of the questionnaire are sufficiently clear to receive correct answers.

The first results show that the questions are correctly understood, since the rate of answers is about 85% among a representative population. Moreover the obtained answers are corresponding to the expected hearing impressions; this allows us to accord a good reliability to this questionnaire.

We address our sincere acknowledgements to the officials, the performers and the listeners which allow us to conduct this study.

6. REFERENCES

[1] M. BARRON 'Auditorium acoustics and architectural design' *ed. E & FN SPON London 1993*

[2] L. BERANEK 'Music, acoustics and architecture' *ed. John Wiley and son's, New York, 1962*

[3] A.C. GADE 'Investigations of musicians'room acoustic conditions in concert halls' Part I and Part. II *Acustica, vol 69 1989 193-203, 249-262*

[4] C. SEMIDOR, Ph. JOUENNE, C. BONHOMME, P. JOANNE 'Qualité acoustique de quelques salles de concert en Allemagne' *in [2ème CFA,1992] Arcachon*

[5] S. AUZILLEAU, A. BARLET 'Analyse des enquêtes auprès des abonnés du Grand Théâtre de Bordeaux et de l'opéra de Lyon' *Rapport interne ERIAC-EAPBx fev. 1996*

[6] C. SEMIDOR, A. BARLET, J. BEAUMONT, S. AUZILLEAU 'Qualité acoustique des salles: problèmes sémantiques posés par le vocabulaire spécifique. Mise au point d'un lexique à l'usage des auditeurs non-spécialisés' *in [4ème CFA,1997] Marseille*