Subjective evaluations in virtual environments

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Introduction

The subjective perception of 3D sound distribution in rooms is still not completely analysed and fully evaluated, even if several experiments were conducted in the last ten years in this specific field. In this paper, the subjective evaluation of room acoustics perception have been analyzed by means or virtual reconstruction of 3D characteristics of ancient theatres, Italian-styled theatres and auditorium. The virtual acoustics of real enviromments has been obtained both by means of Ambisonics based systems and by means of Stereo Dipole based systems, in the Arlecchino listening room at University of Bologna. The realisation of the properly measured filters will be discussed, and the preliminary results obtained gathering several questionnaires about subjective perception will be shown. Afterwards, the most relevant results about the correlation between subjective evaluation and measured, physical parameters, are illustrated.

Previous researches

The finding of correlation between acoustic parameters and subjective evaluations started at University of Bologna since 1994 [1], when a first draft of a questionnaire was prepared following Wilkens' study [2], and afterwards modified and proposed to a set of musicians [3]. In that examples, the correlation between acoustic parameters and subjective evaluations were established by comparing the averaged values of several acoustic parameters, and the personal subjective impressions of several well-known musicians, that were asked to give their opinion about 12 different Italian opera houses. A copy of the questionnaires compiled by M° Scimoni and M° Alberti are reported in figure 1 and 2.

The statistical analysis that was performed during past researches showed a correlation between reverberation time (EDT, T20 and T30), listening level and preference index. However, since the interviewed were asked to give their opinion on theatres, their responses were contaminated by other components, that were not related with the acoustic experience, but rather with their own full experience with the theatre, including thermal comfort, visibility, etc. Therefore, the answers given by the interviewed could have been considerably influenced by other non-acoustical components, including also emotional facts as own experience with the management of the theatre or the audience.

Figure 1: Questionnaire compiled by M° Scimone at Teatro alla Scala, Milan (first version)

Figure 2: Questionnaire compiled by M° Alberti at Teatro alla Scala, Milan (second version)

The *Arlecchino* listening room

In order to properly evaluate the sound distribution in theatres and auditorium, a properly designed listening room was realised at University of Bologna, to precisely reproduce the sound distribution originally measured in the real environments. The Arlecchino listening room is equipped both with Ambisonic and Stereo-Dipole technologies [3, 4], and originally it was utilised for car audio evaluations.
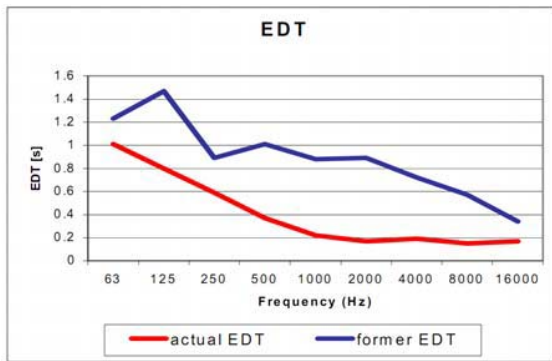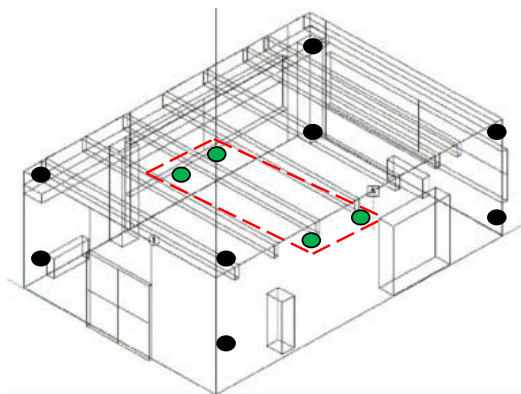

Figure 3 EDT in the Arlecchino listening room

Figure 4 Loudspeakers distribution in the *Arlecchino* room
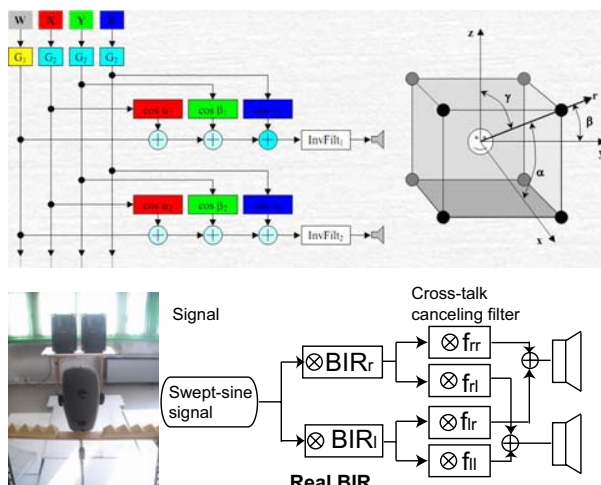
Figure 5 Ambisonics and StereoDipole at Arlecchino listening room

The new questionnaires

After the experiences of the previous surveys developed and statistically analysed in 90-es, a last reduced cersion of the questionnaire was finally proposed and here reported in fig. 7. One of the dfficulties that emerged in those years, was the difficulties to properly understand the meaning of the words utilised in the survey, that could have different (semantic) meanings in different languages, as initialli proposed by Wilkens.

Figure 7 The measuremens at Arlecchino listening room

In order to guarantee the maximum reliability of the surveys, a new version of the questionnaire was developed. The questionnaires was afterwards written in GUI Interface and composed by several modules.

Figure 8 The questionnaire (software version) proposed in 2000

Purposes of the new questionnaires

The new questionnaire has been developed in order to analyse several typology of listeners. The evaluation of acoustic quality in theatres could be expressed in a very

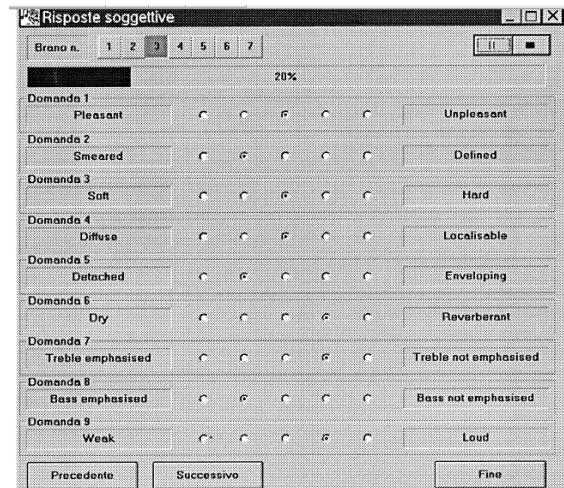different way considering the age, the experience, the acoustic of musical knowledge of the listeners. For these reasons the following categories of listeners were established:

- Musicians who answered as performers

- Musicians who answered as listeners

- Common listeners (without musical experience)

- Ear-trained listeners

These segments of listeners could give considerably different evaluation of sound quality, and therefore might be taken into account.

Transposition of the results among different languages

One of the most inportant findings that might be considered is the different meanings of similar words among different languages. The Wilken's work was based on German language. The translation between German and other languages (English, Italian, etc.) could alter the meaning of some words, because there is not perfect correspondance between the European languages. As an example, the following words have slightly different meanings among languages:

STUMPF BLUNT SMUSSATO   SCHARF SHARP APPUNTITO

KRAFTIG VIGOROUS VIGOROSO   GEDAMPFT MUTED SMORZATO

UNDEUTLICH UNCLEAR NON CHIARO   DEUTLICH CLEAR CHIARO

KLEIN SMALL PICCOLO   GROSS LARGE GRANDE

As a conclusion, in order to draw conclusions about the correlation between acoustic parameters and subjective evaluation, a special care shoud be devoted to the language of the interviewed, since many concerns could relate with the correct understanding of the meaning of the words in the acoustic/psychoacoustic perspective. It is not always feasible to transpose the results among different languages, due to different semantic meanings.

The pre-questionnaire

One of the most important aspect of the validity of the statistical analysis of a questionnaire is the proper understanding of the audio/acoustic effects of the soundwaves. In order to check the awareness of the meaning of acoustic adjectives, as "distorted", high frequency response" and others, a preliminary test was developed. The pre-questionnaire represents a fundamental component of the subjective evaluation, since it allows to consider only the answers given by listeners that are aware of the meaning of the words.

The IRCAM questionnaire

The latest version of the questionnaire was implemented with some questions pairs proposed by IRCAM and related with some aspects of subjective evaluations, as loudness, dynamics and coloration. However, since some words have different meaning in different languages, only some questions were added to the final version.

Figure 9 The questionnaire proposed by IRCAM

The final questionnaire

The final version of the questionnaire includes some of the 8 questions proposed in 2000, and some other questions from the IRCAM questionnaire. Figure 10 reports the screenshot from the software that was specifically written for the purpose.
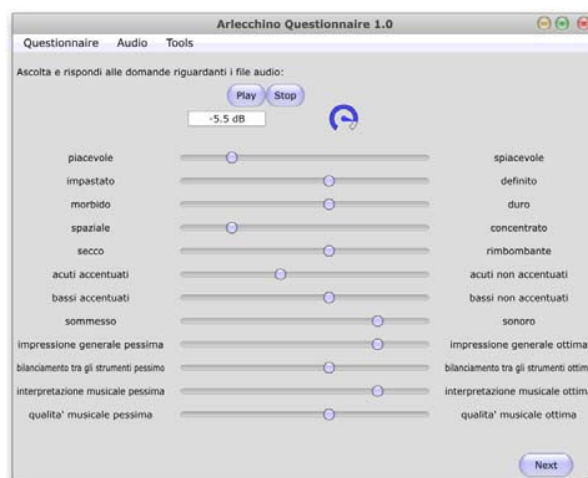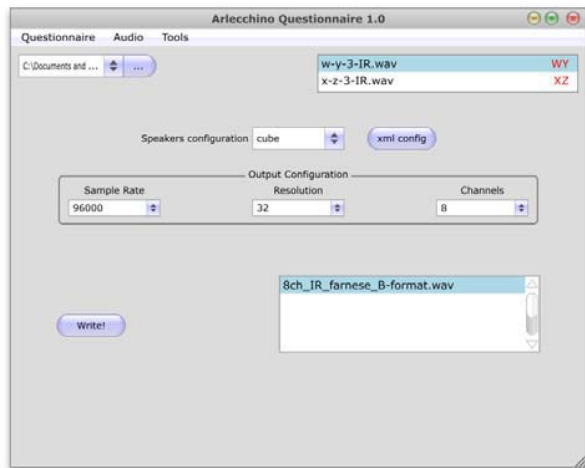

Figure 10 The final version of the questionnaire

The software was written in GUI interface and allows switching in real/time from different playback configurations. Figure 11 reports the switching from Stereo/dipole to Ambisonic (cube) configuration.


Figure 11 The interface between different playback systems at Arlecchino listening room

The different sound configuration allows relating the acoustic playback system to the different results given by the listeners, in order to check any possible relation between the subjective evaluation and the playback method used during the subjective evaluation.

The questionnaire includes two fundamental new components: the rate of each question and the time elapsed during the test. Both the components allow relating the final results with different pairs, since not all the questions were considered of the same importance by the listeners so far. Moreover, the elapsed time during the test is a very important indicator about the feasibility of the answers. Indeed, a very short time or a very long time are both related with a high uncertainty of the results, and underline that the interviewed was not sure about the answers.

The GUI interface

The software that was developed to performe the questionnaire utilises the GUI interface. The following pictures report the flow-chart utilised during the developing of the software, and show the link betwee the playback systems (dual stereo-dipole and ambisonics) in the Arlecchino listening room. The system is equipped with a database of several binaural and b-format impulse responses measured in about 50 historical opera houses in Italy and other Concert halls measured among Europe, Japan and Australia, which includes the new measures of IRs as recently presented [7]. All these IRs could be switched in realtime, and it is possible to change immediately the room where to play the anechoic music.
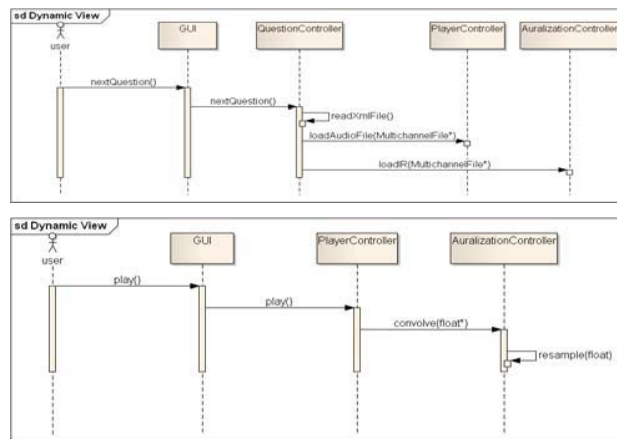
Figure 12 The GUI interface

Conclusions

The new questionnaire here presentes, allows considering a new set of answers in order to properly relate the sound quality in (virtual) rooms with the subjeective evaluation.

The pre-questionnaire allows determining the feasibility of the interviewed and his knowledge of the meaning of the acoustic words normally used. Moreover, the test could also be applied to several different groups of listeners, including musicians, ear-trained people and common people.

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