



Case Study on  
auralisation benefits for  
audience, musicians  
and technical experts

D2.4 of the AURA project



Co-funded by the  
Creative Europe Programme  
of the European Union

### **Project Information**

“AURA - Auralisation of Acoustic Heritage Sites Using Augmented and Virtual Reality” (project no. 101008547)

Project Website: <http://aura-project.eu>

Auralisation – the technique of creating virtual soundscapes in 3D models to provide the same immersive sound experience as the music performed in the real venue. AURA will explore exciting new opportunities that auralisation opens up for music performing arts and their traditional and new audiences.

### **Publisher & Project Coordinator**

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### **Project Partners**

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Konzerthaus Berlin  
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Lviv Polytechnic National University  
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## Table of Contents

<b>1. Introduction: A user-centric approach</b>	<b>4</b>
1.1. Outline of the AURA project	4
1.2. Background: Challenges and user-centric design	6
<b>2. Setting the scene</b>	<b>7</b>
2.1 Focus group: experts at the Konzerthaus Berlin	7
2.2 Protocol of the Recordings in the Anechoic Chamber	10
2.3 Designing a demonstration and lab experience for different target groups	10
<i>2.3.1 The General Public experience</i>	<i>12</i>
<i>The questionnaire</i>	<i>13</i>
<i>The audio experience</i>	<i>14</i>
<i>The audio-visual experience</i>	<i>16</i>
<i>2.3.2 Technicians and Experts experience</i>	<i>16</i>
<i>The questionnaire</i>	<i>17</i>
<i>The audio experience</i>	<i>17</i>
<i>The audio-visual experience</i>	<i>17</i>
<i>Round table discussions</i>	<i>17</i>
<b>3. Feedback Analysis</b>	<b>19</b>
3.1 Focus Group	19
3.2 Collected feedback from the lab experience	22
<i>3.2.1 Results for General Public</i>	<i>22</i>
<i>3.2.2 Results for Technicians</i>	<i>31</i>
<i>3.2.3 Results for Experts</i>	<i>35</i>
<b>4. Conclusions and possible insights</b>	<b>40</b>
<b>5. References</b>	<b>42</b>
<b>6. Appendix I</b>	<b>43</b>
<b>7. Appendix II</b>	<b>54</b>
<b>8. Appendix III</b>	<b>56</b>

# Case Study 1 Documentation

## 1. Introduction: A user-centric approach

### 1.1. Outline of the AURA project

The European project AURA - Auralisation of acoustic heritage sites using Augmented and Virtual Reality – co-financed by the Creative Europe programme, aims to support and encourage new opportunities to use and disseminate Cultural Heritage for Cultural and Creative Industries.

The project is led by the Berliner Gesellschaft für internationale Zusammenarbeit mbH (BGZ), in collaboration with academic partners from the Hochschule für Technik und Wirtschaft in Berlin (HTW), the Departments of Architecture (DIDA) and Industrial Engineering (DIEF) of the University of Florence (UNIFI) and the Lviv Polytechnic National University (LPNU), and with organisations dealing with cultural industries, sound and marketing, the Konzerthaus in Berlin (KHB), with their extensive experience in involving people in immersive experiences and in evaluating their perceptions, the sound engineers Vie en.ro.se. Ingegneria Srl of Florence, adding to the academic approach the knowledge from the business side and reach-out to users, the Lviv Tourist Development Center of Lviv (TDC) and Magnetic One of Ternopil (UA) both investigating implementation and marketing aspects.

Within a context where modern technologies are increasingly used for the enjoyment of cultural heritage, the AURA project aims to tap into the potentials that auralisation opens up for music performing arts and establishments. Auralisation is the technique used for creating virtual soundscapes starting from 3D-models that recreate the sound environment of a real space. This implementation allows to define an immersive experience in which the user can move around in space and can experience how the architecture influences the sound. Specifically, the project intends to explore the potentialities of auralisation techniques to promote European heritage in a new way.

Multisensory 3D models, performing both in terms of graphic rendering and in terms of acoustics, have been developed for three European case studies:

- The Konzerthaus in Berlin, a neoclassical-style building.
- Teatro del Maggio Musicale Fiorentino, which opened in December 2011 and is an example of modern architecture.
- The Opera and Ballet Theatre of Lviv (Ukraine) built in the late 19th century in Neo-Baroque style.



Figure 1: 3D model of the Great Hall of the Konzerthaus Berlin



Figure 2: 3D model of the Maggio Musical Opera di Firenze



Figure 2: 3D model of the National Opera and Ballet Theatre in Lviv

See also the on Youtube video <https://youtu.be/CwRtY3dGAXw> - a recording of the experience in all three venues for comparison (note: the video recording can only give an impression of the immersive sound experience, which needs to be done with HMD and very good quality headphones).

Notably, the three theatres differ in terms of architecture style and period of construction as well as acoustic features. As a matter of fact, they are characterised by different volume, number of seats and reverberation time, which affect the acoustic performance of the theatre.

The three case studies provide models<sup>1</sup> and experimentations with auralisation technologies<sup>2</sup>, technical guidance<sup>3</sup> and marketing strategies to make use of auralisation for exciting new ways of experiencing music. The bridge to new technologies offered by the AURA project's activities will provide a wide range of opportunities for attracting new audiences and promoting new business models and new performance practices. This will be made possible also thanks to the promotion of an approach based on cross-sectoral collaboration and by reaching out to the European music community with its offers, to foster the innovative spirit of their art directors, conductors, and musicians, as well as empower their CTOs, their marketing staff, their service suppliers, their funding and sponsoring agents.

## 1.2. Background: Challenges and user-centric design

The majority of the traditional sectors cultural creative industries still feel a great unease when it comes to introducing new technologies. Though there are wonderful examples of pioneering organisations such as the Konzerthaus Berlin, the Royal Opera House and the Philharmonia Orchestra London, the Finnish National Opera, the Paris Opera, Oper am Rhein and then academic collaborations with cultural institutions such as IRCAM or the Sorbonne ("Vierge2020"), most cultural professionals show an attitude of refusal, possibly linked to the fear of needing IT competences to understand how to work with new technologies. It is a challenge to open the mindset of cultural actors, unless they belong to the experimentally inclined and with a curiosity about the opportunities that new technologies offer.

Linked to this challenge is the fact that many people lack the necessary imaginative power to envision a future scenario or a proof-of-concept. With new technologies, in particular when transferring them to new areas such as here in AURA where auralisation is rather a common technique in sound engineering and architecture, but not at all in the music performance sector. Arguments such as "it is too expensive" or "Head-mounted devices (HMD) and VR application are still not easy to handle" or "the production is too lengthy" stand in the way of seeing the vision and world of opportunities that these technologies would open up. Looking at the history of everyday technologies of the past 2 centuries, one will see how little confidence there initially was in new technologies such as the automobile, TV, PC, graphic cards or mobile phones. Most did not believe they would ever assert themselves on the market. Much as the majority feels today about HMD and VR worlds.

Our user-centric conceptual approach for AURA had to try and overcome these obstacles when presenting the prototype models of the three auralised music venues and asked people, in particular music performers and sound engineers, for feedback on the prospective value outside the pure entertainment value of experiencing a virtual world, which many of the test users did for the first time. The design decisions focused on experiencing the virtual environment as a trigger for edutainment, marketing, organisational and artistic creation considerations. And for this reason we extended the scope of test groups to enclose non-specialists, as we felt that confirmation from the (existing and prospective, future) audience would entice the specialists to overcome their reservations as in "people won't accept HMD-based experiences".

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<sup>1</sup> [https://aura-project.eu/media/aura\\_d2.1.pdf](https://aura-project.eu/media/aura_d2.1.pdf); [https://aura-project.eu/media/aura\\_d3.1.pdf](https://aura-project.eu/media/aura_d3.1.pdf); [https://aura-project.eu/media/aura\\_d4.1.pdf](https://aura-project.eu/media/aura_d4.1.pdf)

<sup>2</sup> [https://aura-project.eu/media/d2.2\\_auralised\\_model\\_of\\_the\\_berlin\\_music\\_venue\\_1.pdf](https://aura-project.eu/media/d2.2_auralised_model_of_the_berlin_music_venue_1.pdf); [https://aura-project.eu/media/aura\\_d10\\_auralised\\_model\\_of\\_the\\_florence\\_music\\_venue\\_1.pdf](https://aura-project.eu/media/aura_d10_auralised_model_of_the_florence_music_venue_1.pdf); [https://aura-project.eu/media/d4.2\\_auralised\\_model\\_of\\_the\\_lviv\\_music\\_venue.pdf](https://aura-project.eu/media/d4.2_auralised_model_of_the_lviv_music_venue.pdf)

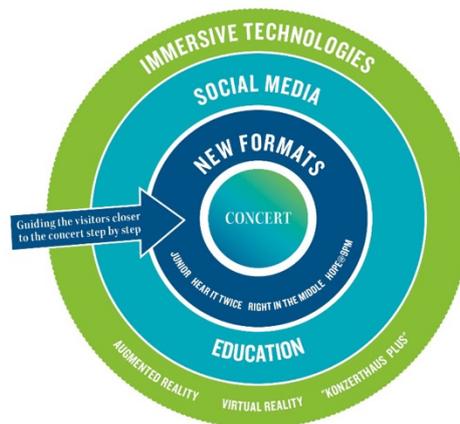
<sup>3</sup> [https://aura-project.eu/media/aura\\_d3-2\\_technical\\_description\\_of\\_the\\_3d\\_modelling\\_of\\_the\\_three\\_venues.pdf](https://aura-project.eu/media/aura_d3-2_technical_description_of_the_3d_modelling_of_the_three_venues.pdf)

To ensure that we get response from many perspectives, we decided to run two different types of tests, one following a script for demonstration with a mixed public in Florence and one as a focus group evaluation with specialists from the Konzerthaus Berlin.

## 2. Setting the scene

### 2.1 Focus group: experts at the Konzerthaus Berlin

Since 2016, the Konzerthaus Berlin has been experimenting with various innovative ways of presenting the music of its own Konzerthausorchester Berlin in the digital space. Various applications in virtual and augmented reality have been developed, such as the world's first virtual quartet in augmented reality and the interactive composition "Umwelten" in virtual reality. The aim here is not to replace the live concert, but to use it to reach younger and more tech-savvy target groups. The digital applications are freely accessible to visitors and interested parties of the Konzerthaus every day between April and October as part of the "Einblick frei" ("Insight free") event. Every month, around 10,000 visitors come to the digital exhibition in the vestibule of the building.



The "AURA" project is therefore a logical development of the Konzerthaus Berlin's digital activities. The possibility of artificially reproducing the real room acoustics in virtual spaces offers various use cases in the different departments of the institution. The idea of soon having all the possibilities of real life also in virtual space (Metaverse) opens up new opportunities, but also entails new challenges. For the Konzerthaus Berlin, facing up to these opportunities and challenges as early as possible, being able to actively accompany and participate in shaping the process, and learning from it as early as possible for the future, is a great opportunity not only to leave the sovereignty of interpretation over the digital space to the large digital concerns, but also to be able to set its own accents.

To be able to correctly classify the assessments of the auralisation in the use cases, a basic description of the special features of the acoustics of the Great Hall in the Konzerthaus Berlin is necessary. The biggest factors influencing acoustics in a room are, on the one hand, the geometric shape of the room, the objects in it and the materials used. In addition, acousticians have optimised the sound in the Great Hall of the Konzerthaus through various installations.

Opened in 1821, the Schauspielhaus am Gendarmenmarkt, as it was then called, was for a long time the home of opera and theatre performances in the neoclassical building designed by the highly renowned Prussian architect Friedrich Schinkel, until the house was almost completely destroyed down to its foundation walls in the last days

of World War II. Reconstruction was not commissioned by the GDR government until in the 1980s. Until then there was no concert hall in East Berlin. At first, they considered building a modern concert hall behind the historic walls, but the architect of the time prevailed and so the classicist style of the facade was adopted for the inside as well. Even though today's interior design is only an interpretation of Schinkel's original, because there was no accurate documentation of the interior views, the architects of the time endeavoured to design the interior in the spirit of Schinkel. In addition to smaller halls such as the Minor Hall, which is used primarily for chamber music and small-scale works, the two Carl Maria von Weber Halls, which are used primarily for events, and the Ludwig van Beethoven Hall, and the modern and flexibly convertible Werner Otto Hall, the Great Hall is the heart of the Konzerthaus. Here, the great symphonies are performed with the in-house orchestra of the Konzerthaus Berlin, but also numerous guest events and gala dinners take place here.



Figure 4: 3D model of the exterior of the Konzerthaus (left), the Gendarmenmarkt and the Französischer Dom (right)

The rectangular shape of the Great Hall is casually called "shoebox". The shoebox shape also provides the best orchestral sound, according to research undertaken by scientists.<sup>4</sup> Differences between the concert halls arise mainly in the high sound frequencies, they account for up to five decibels. But also the decoration of the rooms with pilasters and stucco work and, of course, also the materials used, contribute to an optimal dispersion of the sound. Over the years, however, there have also been optimisations for the acoustics in the Great Hall of the Konzerthaus. For example, above the stage in the side gallery, cladding has been installed and above the stage there are glass sails, the inclination of which can also be adjusted according to the conductor's wishes.

Acoustically, the Great Hall is one of the best symphonic concert halls in the world. The reverberation time is only slightly above the values that room acousticians consider optimal.

However, the hall occupancy is also a significant factor in the Great Hall which seats an average of about 1,400 people, and this also has an impact on the acoustics. For example, it makes a very big difference whether the orchestra plays in front of an empty room, a half-filled hall or a full hall. In rehearsal, some conductors make do with a curtain between the stage and the auditorium in order to hear a reasonably authentic sound even in rehearsal. Because, of course, not only the sound coming directly from the orchestra, but also the reflected sounds from the walls and objects contribute to the overall sound image in a concert hall.

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<sup>4</sup> <https://www.pnas.org/doi/full/10.1073/pnas.1319976111>



*Figure 5: 3D model of the Great Hall*

And finally, the orchestra members and their instruments also function as sound bodies. Sound here is absorbed and reflected by both the human bodies and the instruments. The HTW's auralised model focused primarily on geometric space and objects, using a simplified model of the Great Hall. The very fine and detailed differentiation in the acoustics could not be represented in this first prototype.

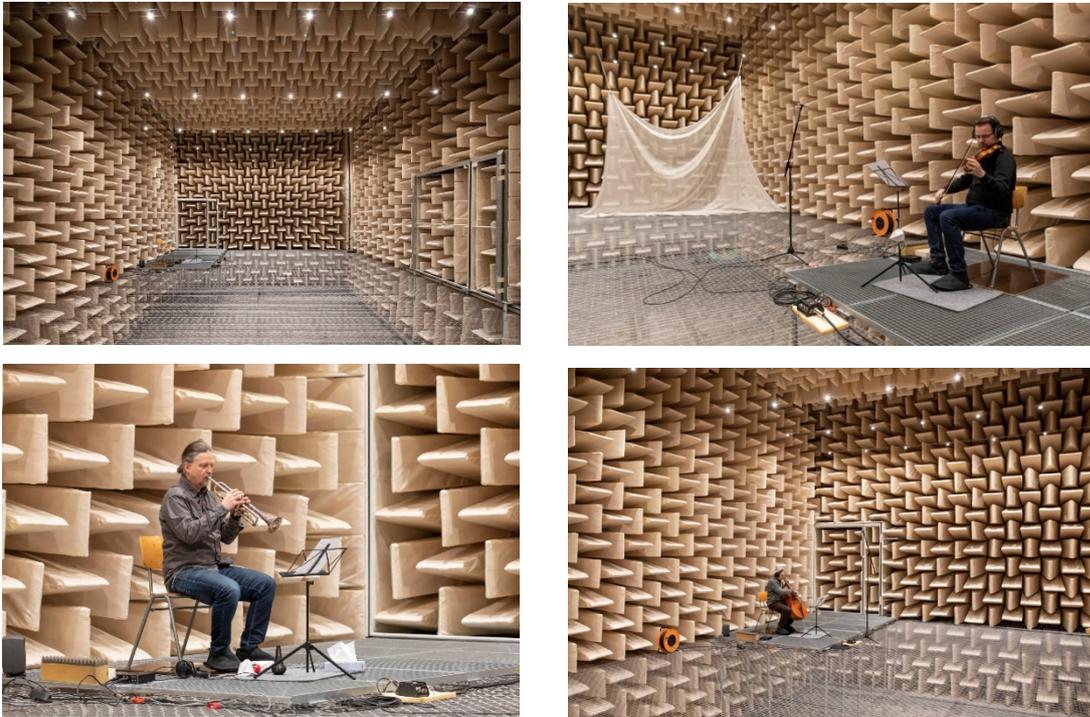
As the focus group encompassed experts from the Konzerthaus, thus knowing the acoustics of the hall very well, we designed following scenario to be used for a productive discussion and sensible feedback:

Only the auralised model of the Great Hall in the Konzerthaus Berlin with static avatars that cannot be moved was used. Within fixed positions, the position in the room can be changed with the controller control and additionally the avatars of the musicians can be faded in or out (individually or in groups). In the VR experience, the hall is without an audience, and the musicians are distributed roughly evenly across the stage. Since there is no traditional way of where the musicians stand in this chamber music setup, they were arranged in an inherently logical line-up. An Oculus Rift S with Sennheiser external headphones was used for testing. In addition, the recording of the music with the separate individual voices in the anechoic room of the Technical University was briefly explained to Focus Group participants. The experience made during these recording needs to be included into the evaluation as it might have an impact on the experts' feedback, as the question of "feasibility" needs to include the prerequisite for the auralisation which is the creation of an anechoic recording of individual tracks per instrument.

We thus include a short summary of the recording procedure.

## 2.2 Protocol of the Recordings in the Anechoic Chamber

On February 8 and 9 of 2021, the Konzerthausorchester Berlin performed in the anechoic chamber at Technische Universität Berlin for AURA recordings. This location was chosen specifically in order to avoid external noises and instrument voice overlapping during the recording. The musicians played individually in the anechoic chamber which effectively removes any acoustic reverberation during the performance.



Photos: Felix Löhnner

As a piece of music, we chose a composition by Claude Debussy. The 4th part "Golliwogg's Cakewalk" from "Children's Corner" is especially suitable for this purpose because all instrument groups appear. The approximately two-minute piece was recorded with the following instrumentation: 1st violin, 2nd violin, viola, cello, double bass, bassoon, clarinet, bass clarinet, oboe, flute, piccolo, trumpet, horn, harp and percussion.

Erik Brauer supervised the recordings as sound engineer, Daniel Ackermann supported us as technical manager. The recordings were edited by the sound engineer and delivered to us in single tracks and in a mixed version. We then forwarded them to the HTW Berlin for further technical processing (auralising the 3D models produced by DIDA-UNIFI).

## 2.3 Designing a demonstration and lab experience for different target groups

The investigation into "Audience Experience of auralised music venues" was dedicated to the evaluation of the perception of the auralised 3D models experiences by different types of prospective user groups.

The design of the lab experience was based on two different sensations that were meant to enhance the potential of "auralisation".

- the pure audio experience using the auralised audio tracks and focusing on the auditory sense
- the immersive audio-visual experience of the virtual reality, which combining the visual with the auditory sense.

The test of the audio-visual experience is intended to collect feedbacks by future users and evaluate the potential of the innovative interconnection between visual perception (already widely experimented on its own e.g. in museums) and sound perception (also experimented on its own, e.g. radio / hifi music systems). We have designed different procedure distinguishing amongst different user/audience groups and the potential benefit or added value the auralisation might offer them.

The user experience and the analysis of their perceptions was thus differentiated in order to collect distinct feedbacks on potential improvements and application of the immersive tool, also based on participants professional experiences.

A sample of 155 participants has been identified and divided among:

- GENERAL PUBLIC (70 participants) including students of secondary schools, non-regular theatre audience, general non-expert public.
- TECHNICIANS (41 participants) including architectural designers, acoustic designers, students of engineering and architecture, promoters of cultural events;
- EXPERTS (44 participants) including musicians, singers, conductors, actors, students of music schools and music Lyceums, general public experts;

Within the “general public” group, we also aimed to assess how young people, who are of the age group least likely to attend theatres and concerts, might perceive the experience. Thus a particular emphasis was given to the involvement of students for educational purposes and youth engagement and, as referred above, to deepen our understanding on how they perceive theatre experience and related virtual reality experiences.

Concurrently, the experts’ and technicians’ opinion has been considered important respectively for a comparison between the real and the virtual experience and for the definition of a model which can better fit the reality and support the acoustic design of spaces.

The immersive experiences took place during the month of May 2022 and October 2022 in the LXR Laboratory of Extended Reality of the Department of Architecture at the University of Florence (Figure 6). In total, eight sessions have been organised in the Laboratory.



*Figure 6 - The immersive experience at DIDA laboratory.*

The following sections will describe in detail how the three groups of subjects have been selected and engaged and how the experience has been conducted, including the design of the questionnaire administered to the three sample groups and the organisation of the round table discussions involving technicians and experts.

In order to reach and engage a broad number of participants for each identified group, several actions were put in place using a wide range of tools and messages tailored to respective target group. Specifically, the sessions of AURA immersive experiences and the AURA project’s main aims were disseminated through the social media accounts of Vie en.ro.se Ingegneria (e.g., LinkedIn) by preparing one pager leaflets (Figure 7).

Additionally, the experiences were promoted through emails and phone calls to Florence music schools, music Lyceums, the Florence music Conservatory, as well as acting schools. Voluntary participants have been also identified during academic courses organised by the University of Florence. In order to ensure a strong participation among technicians, existing networks of the project partners have been also used.

**AURA**  
**ESPERIENZA IMMERSIVA PER IL PUBBLICO GENERICO**

**In cosa consiste?**  
L'esperienza si condurrà all'interno di tre importanti teatri d'opera o di musica: l'Uffizi a Firenze o Berlino, Firenze o Lido di Venezia con occasione di trasferimenti nei teatri appartenenti a tre diversi paesi (sueci, svedesi) in giro per il mondo o approntare diversi punti di vista oltre ad immergerti in una rappresentazione musicale composta da strumenti a fiato, a corda e a percussione. Essendo una società grazie alla tecnica dell'audiovisivo, che permette di creare sceneggiamenti virtuali tramite modelli 3D riproducendo l'ambiente in tutto il suo dettaglio.

**Come si struttura l'esperienza?**  
• Scrittura di interpretazioni audio e audio-video di un brano di musica classica grazie all'uso di cuffie stereofoniche e visori per realtà virtuale.  
• Compilazione di un questionario immediato.  
• Scrittura di esperienze narrative di prima e seconda mano.

**Destinatari dell'esperienza:**  
• Tutti i cittadini.  
• Per i teatri d'opera:  
per il teatro di Santa Caterina  
LIR - DIDA lab Eberhard Reilly Laboratory  
Soleil Saint Tropez  
per il teatro di Accademia Musicale  
Orchestra degli Stati di Firenze  
Via della Mattiotta, 24 - Firenze  
Dopo averne il corso di programmazione nel periodo di maggio-giugno 2022.

**Dove?**  
Firenze

**Quando?**  
Dopo averne il corso di programmazione nel periodo di maggio-giugno 2022.

**Durata**  
5 ore

**1 INTRODUZIONE ALL'ESPERIENZA**  
**2 COMPILAZIONE QUESTIONARIO**  
A. DATI PERSONALI  
**B. ABILITÀ RELATIVE ALLA FRUIZIONE ED ESPERIENZA PROFESSIONALE**  
**3 ESPERIENZA AUDIO**  
You are listening to the clarinet from the first row  
**4 COMPILAZIONE QUESTIONARIO**  
C. ESPERIENZA AUDIO  
**5 ESPERIENZA AUDIO-VIDEO**  
**6 COMPILAZIONE QUESTIONARIO**  
D. ESPERIENZA AUDIO-VISIVA  
**7 COMPILAZIONE QUESTIONARIO**  
E. CONFRONTO TRA LE ESPERIENZE  
F. SVILUPPI FUTURI

Vuoi ricevere maggiori informazioni sull'iniziativa e sperimentare questa esperienza immersiva?  
Contattaci allo: 055 4191440 (Dopo le ore lavorative Ingegneria) | Email: [guida@vies.ro.se](mailto:guida@vies.ro.se) | Ing. Paolo Pulella - [pulella@vies.ro.se](mailto:pulella@vies.ro.se)  
Visto? Punte: <https://www.unicofirenze.it/2022/>

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**BGZ** **MagneticOne** **Università di Firenze** **Vie en.ro.se** **htw** **Hochschule für Technik und Wirtschaft Berlin** **Humboldt-Universität Berlin** **LVIV**

Figure 7 - The leaflet designed to engage participants of the General Public group.

### 2.3.1 The General Public experience

To ensure that experiences run smoothly, participants were divided in small groups of 4 people and introduced in the DIDA Laboratory. Here, the technical supervisor presented the AURA Project and briefly described the audio and the audio-video experiences as well as the questionnaire they were asked to fill in before and after the immersive sessions.

Figure 3 summarises the subsequent phases of the experience that were carried out by the participants of the General Public sample group.



Figure 3 - Subsequent phases of the experience (General Public).

### The questionnaire

The survey was designed drawing on results and set of questions deployed by recent projects in the field of performing arts which mainly aim to:

- i) collect robust data on audiences including demographic profile and booking behaviours (see e.g. the audience evaluation reports by the Audience Agency available at [www.theaudienceagency.org](http://www.theaudienceagency.org));
- ii) identify audience members’ motivations to attend arts and music performances (see e.g. the report “Opera Patrons ABA Audience Survey Data” available [here](#)) and
- iii) explore benefits people enjoy from music, barriers to concert attendance as well as strategies to creatively engage audiences (Dilokkunanant, 2019; Baker 2000).

The questionnaire was created using Google forms (Figure 8). In this way participants were given the possibility to fill-in the set of questions on their mobile phones, scanning the corresponding QR Code, or alternatively, on a PC.

Figure 8 - An extract from the Questionnaire for General Public.

The structure of the questionnaire consists of 30 questions divided into six main sections. The first part of the questionnaire includes:

- Section A on personal information composed of 5 questions, designed to collect data in relation to age, gender, education, occupation, and nationality.
- Section B with 10 questions, focusing on personal habits and behaviours related to fruition.

The second part is composed of one section:

- Section C with a single matrix question focusing on the evaluation of the audio experience.

The third part includes three sections:

- Section D composed of 6 questions on the evaluation of the immersive audio-visual experience.
- Section E, composed of 3 questions, which focus on the comparison between the immersive audio-visual experiences in the three theatres.
- Section F on future developments, with 5 questions that deal with the potential of the auralisation tool as regards theatre and performance attendance in virtual reality.

The questions included in the questionnaire are closed-ended questions, and some of them are multiple-choice questions. The set of questions is preceded by a short introduction on the AURA project and the overall aim of the survey. The full questionnaire template, translated in English language and including an introductory section presenting the project and the survey, is made available in Appendix I.

Before starting audio experience, participants were asked to answer to the questions of the first part of the questionnaire (sections A and B).

### **The audio experience**

During the audio experience participants, using stereo headphones, listened to the fourth part of "Golliwogg's Cakewalk" from "Children's Corner" by Claude Debussy auralised in one of the case studies: the Konzerthaus in Berlin.

The audio track consists of different instruments playing inside the theatre and in different listening positions, according to the following structure:

- Listening to the whole orchestra from the stage (20 seconds).
- Listening to the whole orchestra from the balcony (20 seconds).
- Listening to the whole orchestra from the first row (20 seconds).
- Listening only to the clarinet playing from the first row (15 seconds).
- Listening only to the clarinet playing from the side stage (15 seconds).
- Listening only to the violine playing from the stage (15 seconds).

The description of the content of each part of the audio track, that is the playing instrument(s), and the position in the theatre from which each participant was listening to it (e.g. from the first row) were displayed on the PC monitor (see 9).



Figure 9 - Information on the audio experience as displayed on PC monitor.

At the end of the audio experience, participants answered to Section C of the questionnaire, concerning the (virtual) audio experience in the above-mentioned theatre.

In order to better engage youth participants, an Audio Interactive Game was also designed. Students were asked to listen to an audio track and to recognize the instrument or the kind of instrument playing and understand how close to the orchestra he/she was listening to the specific section of the music track. The interactive quiz was implemented in Microsoft Forms and the correct answer was displayed on the screen as soon as the answer was given by participants (Figure 10).

The Interactive Game is composed of the following scenarios:

- Listening only to the clarinet playing from the first row (maximum 10 seconds).
- Listening only to the harp playing from the first row (maximum 10 seconds).
- Listening to the violine, violoncello and double bass playing from the first row (maximum 10 seconds).
- Listening to the Flute, oboe and trumpet playing from the first row (maximum 10 seconds).
- Listening to the whole orchestra from the balcony (maximum 10 seconds).
- Listening to the whole orchestra from the stage (maximum 10 seconds).

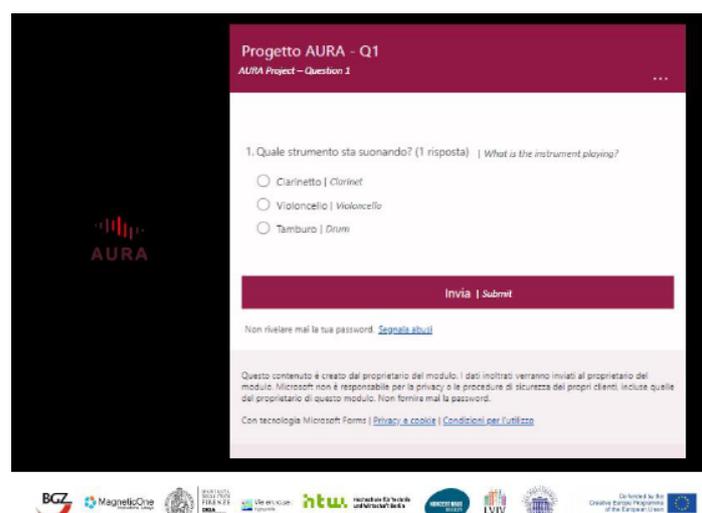


Figure 10 - The interactive quiz for the Audio Game.

The interactive quiz designed for the game and translated in English is made available in Appendix II.

### The audio-visual experience

In order to prove the audio-visual experience, the technical supervisor provided an Oculus (a virtual reality headset that allows to play the audio and the 360°-view of the space) to each participant and run the Apps of the three theatres so that users listened to the auralised audio tracks (the Debussy piece referred above) and visualised the corresponding space in the Oculus.

Participant led the experience and independently choose the listening positions within each of the three theatres (e.g. on the stage, front rows, balcony seats etc.) (Figure ). The audio track consists on the Debussy piece played by the whole orchestra.



Figure 11- The audio-visual experience (visualsation from two different positions in s Teatro del Maggio Musicale Fiorentino -left- and Konzerthaus -right)).

At the end of the immersive experience, participants were asked to answer the third part of the questionnaire (sections D, E, F).

### 2.3.2 Technicians and Experts experience

The experience designed for technicians and music experts slightly differs from the one carried out with the general public, in order to suit the peculiar characteristics of the sample groups. The main variation deals with the round table discussion carried out to gather feedbacks on multiple aspects of the proposed experiences and on potential applications of the auralised 3D models.

Figure 12 shows the subsequent phases of the experience that was carried out by the sample groups of technicians and experts.



Figure 12 – The experience phases for General Public.

## **The questionnaire**

The structure of the questionnaire administered to technicians consists of 11 questions divided into 2 sections:

- i) section A, with 5 questions, which aims to collect personal information (age, gender, education, occupation, and nationality)
- ii) section B, with 6 questions on habits regarding theatre attendance and on professional experience.

Similarly, the questionnaire designed for music experts is composed of 15 questions divided into 2 main sections: i) section A, with 5 questions focusing on personal information (age, gender, education, occupation, and nationality) and ii) section B, with 10 questions on habits regarding theatre attendance and professional experience.

The two questionnaires' templates are made available in Appendix I.

## **The audio experience**

Before starting the audio experience, participants were asked to fill in the entire questionnaire.

The audio experience was carried out as described in the section above concerning the General Public sample group. In this case the Interactive game was not performed.

## **The audio-visual experience**

The audio-visual experience was carried out as described in the section above, concerning the General Public sample group.

At the end of the audio-visual experience, a round table was organised to collect experts' feedbacks and ideas concerning pro and cons of the tool and potential applications and uses.

## **Round table discussions**

Two specific canvas – one for each participants' sample group – were elaborated and displayed on a screen and printed to facilitate the discussion on specific topics. Suggestions, comments and ideas were collected on a personal computer by the staff conducting the experience.

In particular, as regards the round table with technicians, the following aspects were touched upon:

- other potential applications of auralisation in their field,
- utility of the immersive experience tool for the choice of materials in a designer project,
- benefits of the tool in the field of architectural design,
- added value compared to traditionally used tools,
- specific benefits for acoustic designers.

Music experts were instead asked to discuss and give their feedbacks and opinions on the following topics:

- previous experiences with immersive technologies,
- benefits of listening from different points of the theatre,
- benefits of knowing the architecture and acoustics before the performance,
- benefits of activating / deactivating different music instruments,
- utility for a specific type of theatre or performance,
- effectiveness of the immersive experience tool in attracting new audience.

As shown in Figure 13 and 14, for each main topic in the diagramme, a related question – on the right side – was used as a point of reflection and to facilitate and catalyse the discussion.

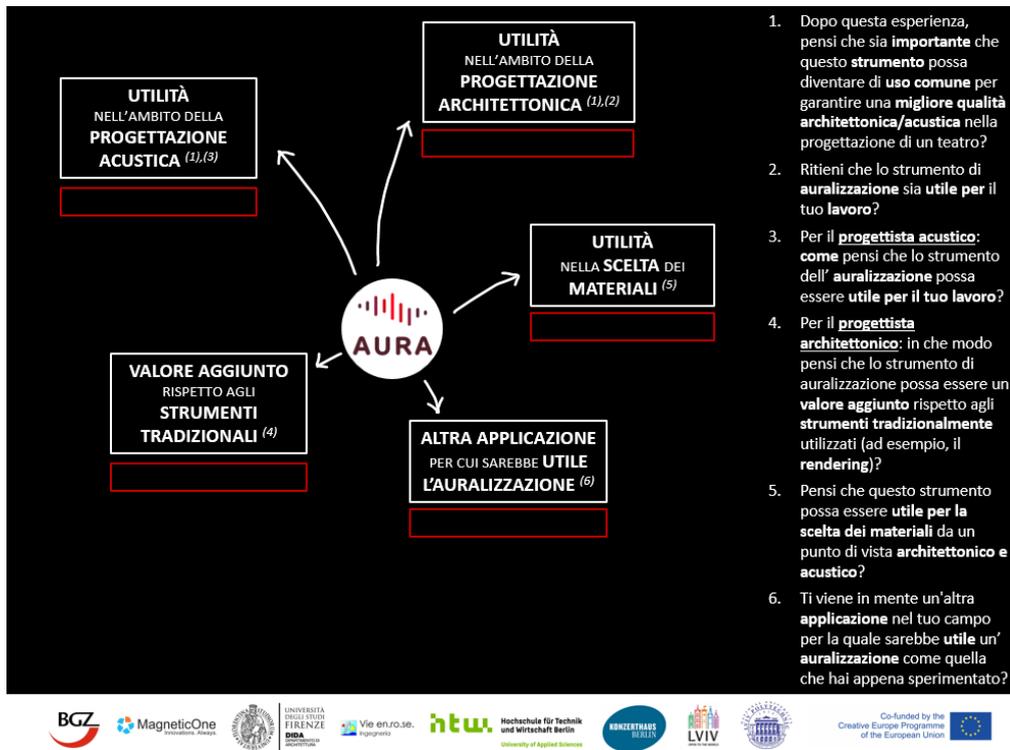


Figure 13 - Canvas for Round Table discussion (Technicians).

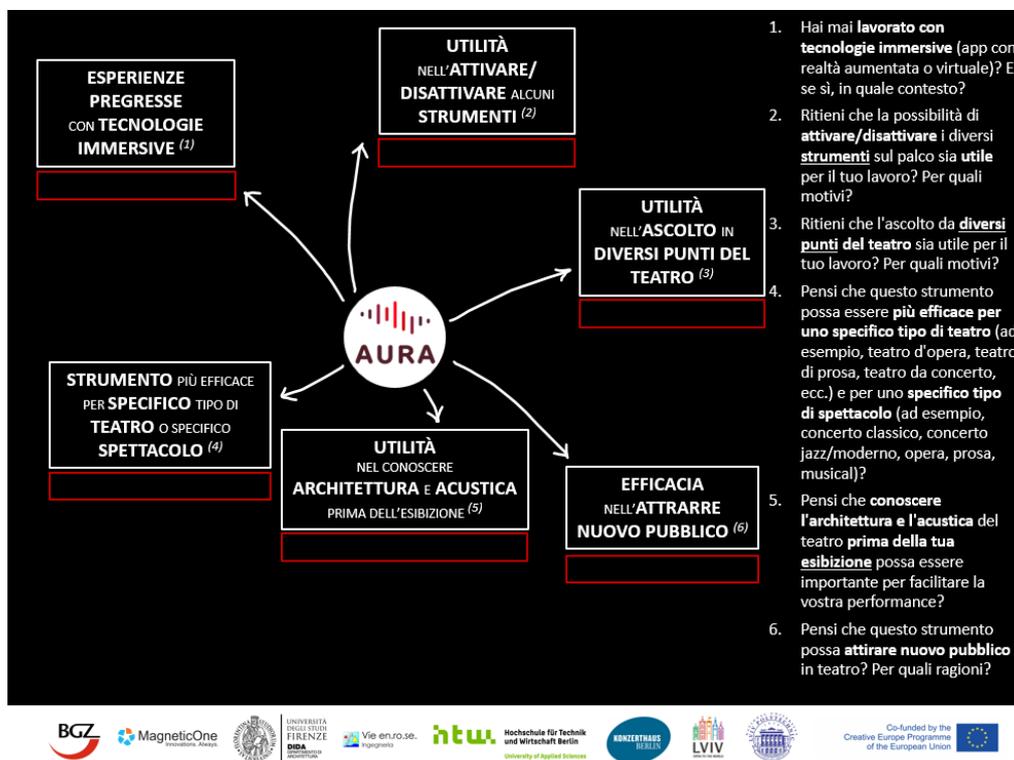


Figure 14- Canvas for Round Table discussion (Experts).

The main topics discussed during round tables are also listed and translated in English in Appendix III.

## 3. Feedback Analysis

### 3.1 Focus Group

The focus group was formed of Konzerthaus professionals. First, the quality of auralisation was evaluated by musicologists. The evaluation of the auralisation is difficult because an expectation of the spatial sound can only be formulated here under the conditions of an empty hall and certain positions, because a reference recording under real conditions is difficult and extremely time-consuming to reproduce, also requiring very powerful computers. Therefore, this assessment refers exclusively to the auralisation of the Great Hall of the Konzerthaus because the experts interviewed at the Konzerthaus Berlin were very familiar with the acoustic reality of that auralised room.

In addition, there is the type of recording. All instrumental parts were recorded in the anechoic room of the Technical University of Berlin (see 2.2). Since the orchestra members did not play together and the voices were then mixed afterwards, the recording is not comparable to a recording in which the orchestra would have played together. Playing together with the conductor or concertmaster creates its own dynamic, which cannot be transferred to the mix of individual voices. Here one must make compromises as long as it is necessary to record these individual voices and the source separation is not yet possible in a joint recording.

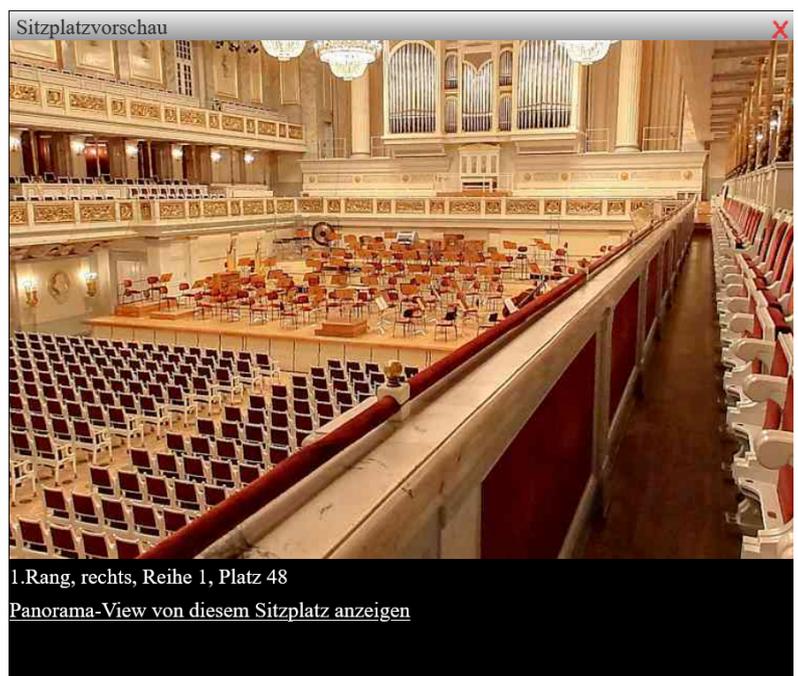
Therefore, the artistic quality of auralisation has its limits (also in authenticity), which were also stated. According to interviewed experts, the positions are distinguishable from each other. It was noted that the clarinet was perceived as too present and loud in all positions compared to the expectation. The bassoon and horn were described as too muffled. In the positions in the orchestra, the strings were perceived as too undifferentiated.

With the auralisation of the Great Hall by the HTW with the 16 individual voices and the static avatars of the Konzerthausorchester Berlin, the Focus Group evaluated the various aspects of potentials of auralisation. Internal and external experts were involved in the process. Certain scenarios were specified for the evaluation, other possible use cases were designed by the experts themselves and emerged in the discussion. The following use cases were discussed in detail:

- **Added value in ticket sales:**

In the ticket webshop at [www.konzerthaus.de](http://www.konzerthaus.de), it is already possible to buy tickets according to visual axis. Auralisation would make it possible to extend this offer to the acoustic auditory impression of a specific seat in the auditorium.

The ticket purchase with an acoustic impression provides added value for the Konzerthaus Berlin. The technical feasibility and the need to offer music of different genres must be taken into account. For example, a differentiation would have to be made between symphonies, vocal performances and musical works with soloists. The experts also agreed that, if a selection is made, the hall should already be about 2/3 full and that not every seat would need an individual auralisation, but that a division into eight sections of the hall would suffice because the acoustic differences per seat are too small. From the experts' point of view, an



implementation as an app for VR glasses does not make sense for domestic use at the moment. In the medium term, implementation as a desktop application in connection with the purchase of tickets in the web store would be attractive. If tickets are purchased in the visitor service, an immersive type of purchase, e.g., with AR or VR technologies, would also be conceivable in the medium term. Since the Konzerthaus Berlin already offers a digital exhibition, this would be a conceivable addition. However, the experience would then also have to be adapted accordingly. Processes for customer satisfaction must be established should a seat not meet expectations during the visit.

### **Potential of a virtual concert visit**

With the digitisation of historic buildings and the possibilities of auralisation, the potential of a purely virtual concert visit is obvious. Mark Zuckerberg has already drawn up a possible scenario with his vision of the metaverse, in which all the possibilities of a real world would also be available virtually. Even though this may still be an idea that lies far in the future, the major digital corporations are already working toward preparing the prerequisites for such scenarios. This includes the relocation of live events from cultural events such as concerts and theatre performances into virtual space. But other scenarios are also conceivable in which a virtual visit can be a useful supplement to the analogue visit. For example, renovation measures may mean that venues cannot be visited for many months. The Covid19 pandemic led to months of venue closures. Or venues may be temporarily unavailable to visit due to dramatic events such as fire or the destruction of war.

In addition, there are many people who can no longer come to the concert because of age and illness. In the last season before the Corona pandemic, the concert hall had over 5,000 customers who bought a subscription. The average age of subscription customers is 76. There is also constant feedback that customers can no longer continue their subscription due to age or illness. In addition, studies show that older people with limitations due to dementia can orient themselves much better if they can be transported back to familiar situations. This would certainly require a revision of the Experience, the avatars would have to be more lifelike and move, and interaction possibilities would also have to be worked on under certain circumstances. The experts at Konzerthaus Berlin do not see this scenario as a good opportunity for monetization, but such projects could certainly be further developed together with partners from the care sector. AURA has made a valuable contribution to thinking about such approaches and, if necessary, developing follow-up applications.

Experts also discussed potentials in the organisation of rehearsals and events. Two aspects need to be considered here: On the one hand, the technical preparation and stage set-up for own events and the area of renting to outside events. For the company's own events, a lot of preparation is needed on stage to ensure a smooth concert. For example, paper sketches are used in the preparation of an initial list of where which console should be located and where soloists should stand, if necessary. The orchestra and music stands are then set up together with the orchestra's directors, stage technicians and artistic directors. For the preparation, it would be very useful to be able to carry out this rehearsal digitally in order to save personnel and time resources. For the technical preparation, the data from "AURA" is very valuable, but the needs of the technical department are much more differentiated than in the current applications. For example, the orchestra wardens need for their work not only the musicians, but also the chairs, music stands, if necessary stands for instruments and all instruments that can occur in a concert. The Experience now with only the musicians is not optimally suited for this - in addition, there are the already explained limitations that the music sounds realistic. Nevertheless, the specialist department can now continue to work with the existing data and possibly develop their own projects from it.

Renting out the Konzerthaus Berlin is an important economic factor. Every day, the Konzerthaus Berlin receives 7-10 inquiries as to whether the house can be rented for events. These are on the one hand concerts organised by third parties, where the Konzerthaus participates in ticket sales, but also requests from companies to rent the house for ceremonies or galas. It would be all the more valuable to provide as much information as possible in advance in order to ensure the most accurate preparation possible, saving both personnel and time.

The need to be able to fall back on virtually visualised support for rentals is very high. Especially for special events, where the hall is de-chaired and then the room is used differently, e.g. as a space for a gala dinner, visualised

assistance with VR or AR would be very helpful in showing what possibilities the halls of the Konzerthaus can offer when arranged differently. The acoustics are less important in these requests because concert organisers assume that the acoustics in a concert hall like the Konzerthaus Berlin meet international standards. Besides, artists and musicians do a sound check shortly before the performance anyway to clarify practical and technical aspects of the performance as well. According to the experts, a preview in a virtual room would have no discernible added value.

The possibility of using auralisation for music education was also discussed. The Konzerthaus Berlin uses immersive technologies primarily to open up new target groups and to enable experiences that approach music differently. Auralisation could be a way to enable audiences to experience new listening impressions in virtual space and to participate interactively in a concert. The remarkable thing about concerts in virtual space is that here the relationship between audience and artists on stage can be broken up, enabling a whole new stage space. Users can change positions, take up different positions in the orchestra and in the room, and thus understand music and acoustics in a playful way. The current application is still relatively limited in its possibilities, but through a further development with e.g. volumetrically recorded avatars that move, the auralisation can be used to experience classical music individually, possibly also with several people together. The application could then be used equally in schools and in the education program at the Konzerthaus Berlin.

Finally, possibilities of auralisation for artists such as composers, conductors and musicians were discussed. Here, the experts agreed that the quality of the tested experience does not yet come close to reality and that it is therefore difficult to actually consider its use in the artistic field, which is why the evaluation here remained rather general.

Technical support is now part of everyday life for many composers. The expert involved in the evaluation has often worked with the possibilities offered, for example, by the Vienna Symphonic Library software and other providers. Recorded instruments can be used, but also so-called room packs that simulate the sound in specific rooms (such as in the Vienna Konzerthaus or in legendary recording studios like the Abbey Road Studios or the Hansa Studio). Since it is rare to compose for a specific location, this simulation is a good option, but must also be used well by composers so that it provides real added value and is not just a technical gimmick that interferes with the focus of the work. The situation is different in other contexts, too, software-based spatial sound is already being used by orchestras and especially choirs to prepare for concerts in specific concert halls. This is a tried and tested method which can be used to good effect, especially with amateur musicians, in order to prepare rehearsals in an appropriately targeted manner. The added value of an additional visual impression in virtual reality of the concert hall is considered by the experts to be rather low. Moreover, the experts cannot really imagine how this can be implemented in practice. If an entire orchestra puts on VR glasses, how can they still play the instruments? Musicians would also benefit from an application that allows them to rehearse virtually with other musicians in a specific concert hall in order to prepare concerts and have the opportunity to make music together from different locations. Again, since the Corona pandemic, there have been teleconferencing tools that are optimized for musical needs and make it possible to make music together with almost no latency. The experts asked do not see any added value in visually illustrating this music-making in virtual reality.

## Feedback Summary

Auralisation has great potential for theatres and concert halls in the various fields - especially when thinking of future developments such as the Metaverse, where the possibilities of analogue space are to be transferred to the virtual world. Inquiries about projects similar to AURA, which have been made to the Konzerthaus Berlin in recent months by large digital companies such as Siemens or Huawei, confirm this assessment. However, for auralisation to be implemented in concert and theatre operations with added value for the institutions, the technical implementation must be changed and optimized. In addition to the human and time resources necessary to be able to perform appropriate laser scanning recordings, the following factors must be considered:

- The recordings must function as a complete recording and the source separation must also be possible in a complete recording.

- The experience must be attractive (for example, with moving avatars as a volumetric video) and, looking to the future, social interaction with other virtual visitors should also be possible.
- The auralisation must be authentic and also take acoustic subtleties into account.

But for the Konzerthaus Berlin, AURA offered the chance to get the laser scan recordings, which we were already able to use very well during the project. For example, a virtual evacuation rehearsal was carried out with the data, and we identified numerous potentials in leasing and technology, where new projects have opened up and which the Konzerthaus would like to explore further. The use cases have also ensured that scenarios have been discussed in the house and can be addressed for a later date.

### 3.2 Collected feedback from the lab experience

The total number of participants to the AURA immersive experiences was 155, which corresponds to the same number of collected and completed questionnaires distributed as follows:

- 70 completed questionnaires by the General Public,
- 41 completed questionnaires by Technicians,
- 44 completed questionnaires by Experts.

Additionally, field notes of the round table discussions with a total of 85 participants (divided into smaller groups) were collected and analysed.

#### 3.2.1 Results for General Public

##### **Demographic profile and habits related to theatre attendance**

Concerning section A on “personal information” of the questionnaire administered to the general audience, results show that the number of female participants is greater than the male one (44 versus 26) and the majority of the respondents of the sample group is in an age range between 18 and 40 years. A great majority of the respondents, corresponding to 89%, has at least a high school diploma (Figure 15). Moreover, as regards their occupation, the largest group (65%), 45 out of the total of 70 respondents, corresponds to students (Figure 16). The great majority of respondents are Italian citizens.

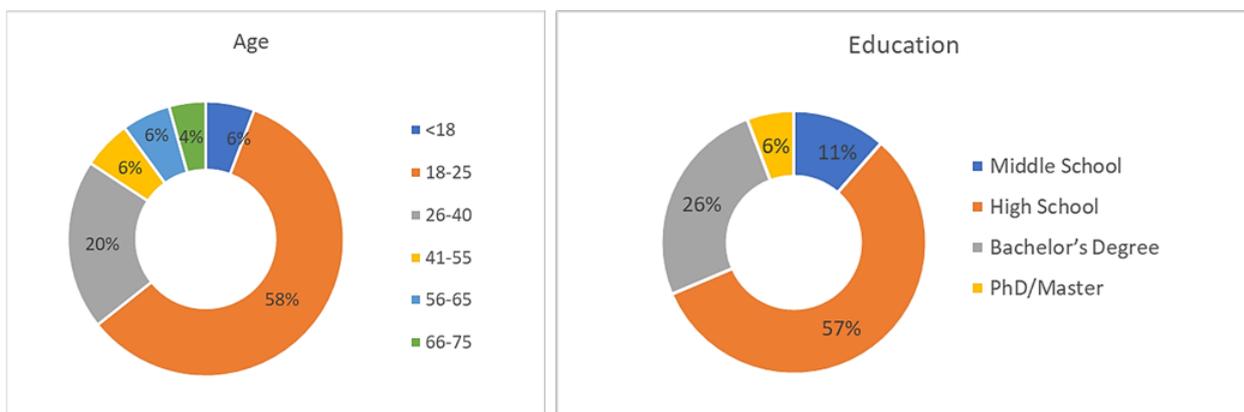


Figure 15 Charts on Age and Education – frequency distribution (General Public).

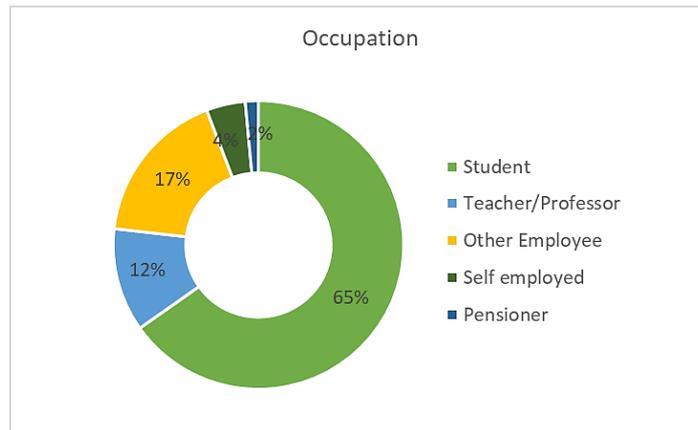


Figure 16 - Chart of Occupation – frequency distribution (General Public).

As regards frequency on cultural events attendance (theatres, cinema, concerts etc.), there are differences within the sample: 39% of the respondents attend more than 6 cultural events a year, while 24% of the respondents attend a cultural event 1 or 2 times a year. Less of 10% of the subjects attend a music performance more than 5 times a year (Figure 17). All in all, these results show that the General Public group is composed of a majority of non-theatre goers, that is persons that do not regularly go to the theatre. Classical plays, jazz and modern concerts and musical are the preferred theatre exhibitions genres (Figure 18).

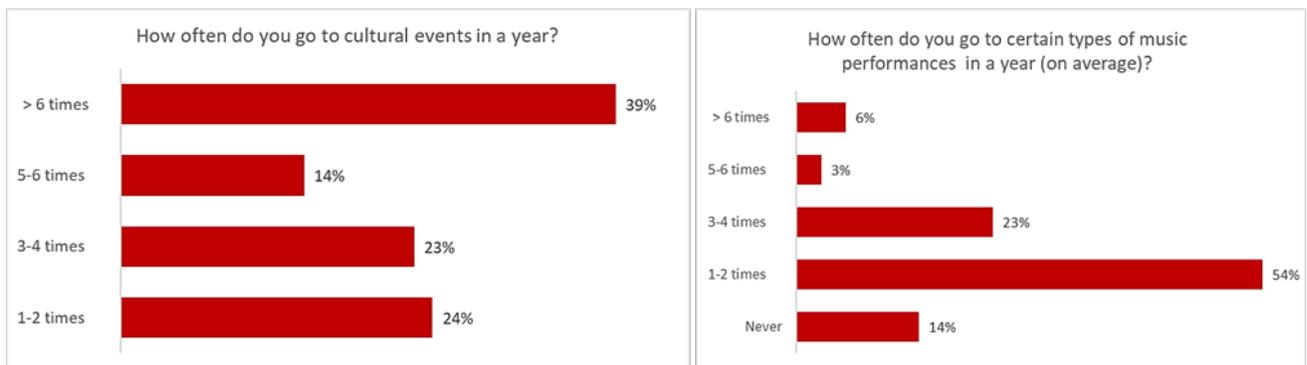


Figure 17 - Charts on cultural events attendance (General Public).

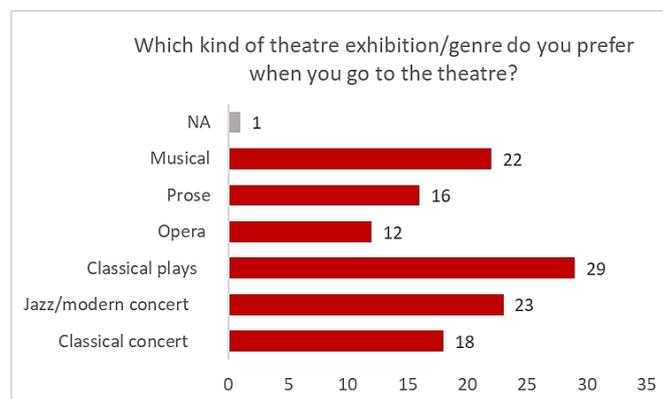


Figure 18- Chart on preferred theatre genre (General Public).

When confronting with the question “Why you go to music theatre?” the motivations indicated with more frequency are: i) to listen to a richer, louder, more real sound, indicated by 31 subjects out of 70, ii) to enjoy an event that has a great visual impact (27 out of 70), iii) to spend a special evening in the company of friends and/or family (26 out of 70) (Figure 19).

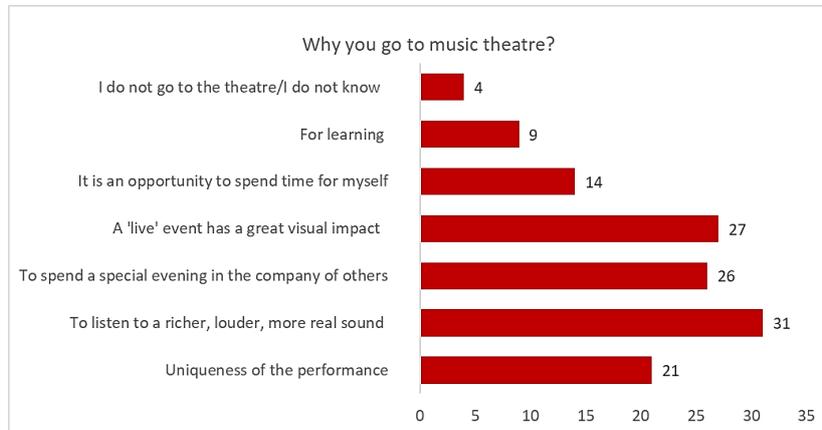


Figure 19– Chart on motivations of theatre attendance (General Public).

These motivations are in part reflected in the answers given to the subsequent question (Figure 20) which focuses on the different characteristics of distinct type of shows and cultural events usually enjoyed at theatre. Indeed, according to a relevant number of respondents, it is preferable to enjoy classical concerts (41 respondents out of 70), classical plays (39 out of 70) and opera (30 out of 70) at theatre rather than on TV. However, it is also important to note that the same shows are not considered affordable, especially compared to jazz and modern concerts. Also, according to respondents, it seems that it is difficult to find and enjoy a wide selection of opera and musicals.

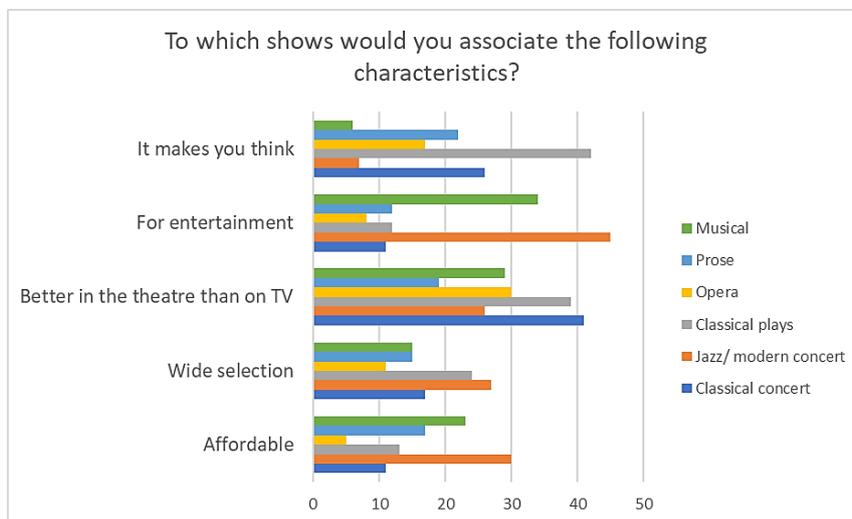


Figure 20 – Chart on the characteristics of theatre shows (General Public).

The great majority of respondents (80%) usually enjoy music listening to streaming music. Some participants also enjoy music by listening to the radio (12%). Instead, “Enjoying music at theatre” is the option chosen by just 3% of the sample. (Figure 21).

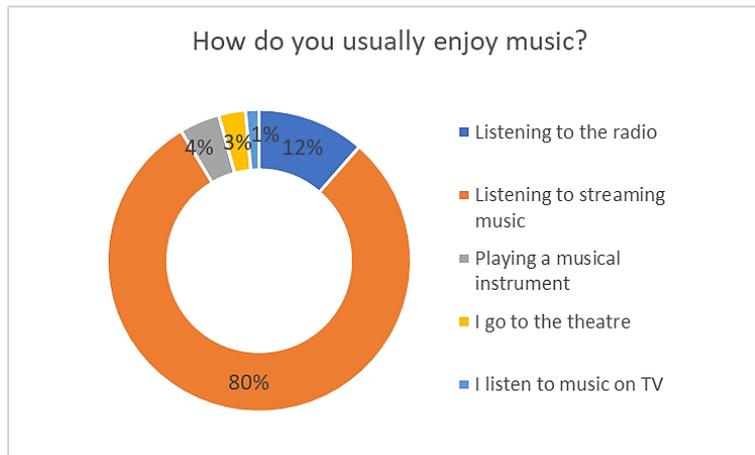


Figure 21 – Chart on modalities of music listening (General Public).

Almost 30% of the General Public participants enjoys stream music shows more than 3 times in a year. Comparing these results to those presented in Figure 14, regarding the in-person attendance to live music performances, Figure 22 shows that this portion is a little higher than the share of subjects who enjoy in-person music shows with the same frequency. Notably, 24% of respondents never enjoy music through streaming platforms.

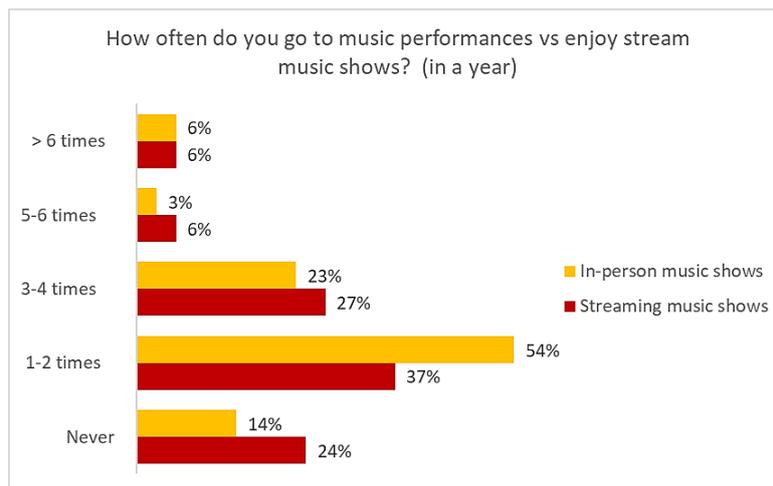


Figure 22 - Chart on in-person music shows vs streaming music (General Public).

As presented in Table 1, half of the sample has never attended a live performance in any of the three theatres which are reproduced by the AURA multisensory 3D models.

Have you ever attended a live performance in one of these theatres?	
Konzerthaus (Berlin)	4
Teatro del Maggio Musicale Fiorentino (Florence)	34
Lviv National Academic Opera and Ballet Theatre (Lviv)	2
None of these	35

Table 1 - Theatre attendance in the three case studies (General Public).

### Audio experience

The results concerning the section of the questionnaire that is intended to collect feedbacks on the audio experience, show that a relevant portion of the sample (43%) perceived significant differences when listening to the same piece of classical music from different points of the theatres (Figure 23). This demonstrates that the results of the application of auralisation technique is very much appreciated by non-theatre goers.

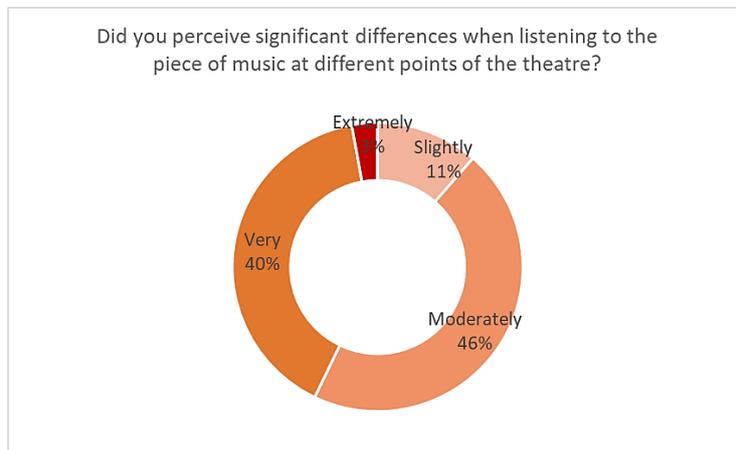


Figure 23 - Chart on audio experience (General Public).

Furthermore, according to a great majority of the sample (67%), enjoying the possibility to listen to the piece of music from points of the theatre which are usually difficult to access (e.g., the stage) or less affordable (e.g., the front row) is an added value compared to the real experience. The majority of the sample also valued with at least “very” the extent to which the possibility of changing the number and type of instruments provides a significant added value compared to the real experience (Figure 24).

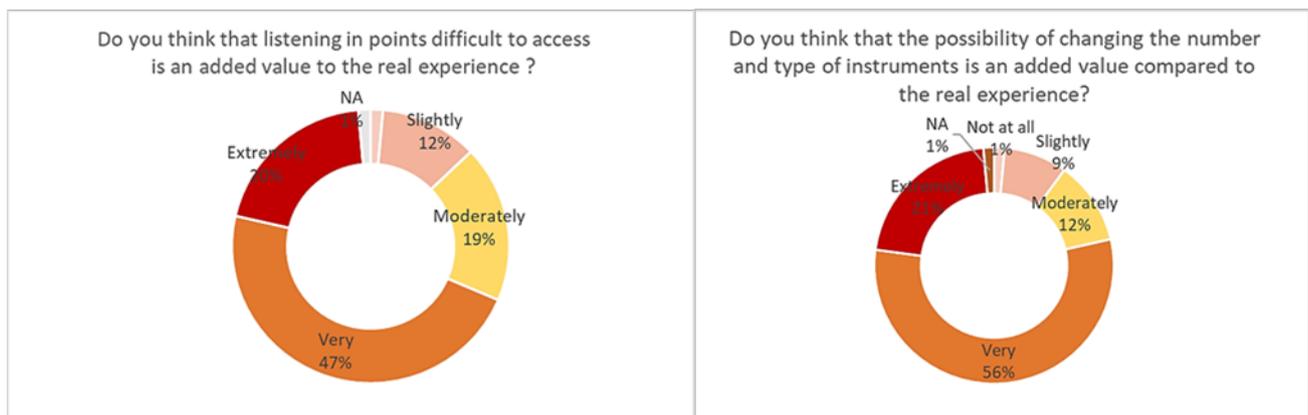


Figure 24 - Charts on comparison between virtual audio experience and real experience (General Public).

93% of the participants declared that the audio experience had met its expectations at least “moderately” (Figure 25).

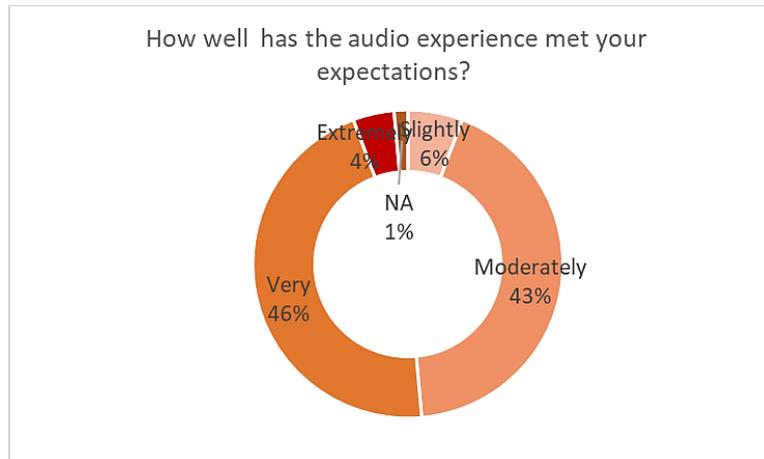


Figure 25 - Chart on audio experience evaluation (General Public).

### Audio-visual experience

When asked to assess the immersive audio video experience in the three theatres, 32% of the participants of the general public group indicated that had perceived significant acoustic differences when listening to the same piece of music from different points of the theatre. 47% of the respondents perceived acoustic differences in a moderate way (Figure 26). It is interesting to note that these results, in details, slightly differ from the results concerning the assessment of the audio experience. In the latter case, the portion of the participants that indicated that they perceived acoustic differences depending on their position as “very” significant was 40% and as “extremely” significant was 3% compared to, respectively, 26% and 6% in the case of the audio-visual experience. This may partly be explained by the fact that participants in an immersive experience focused their attention not only on audio elements but also on visual elements of the 3D virtual reality.

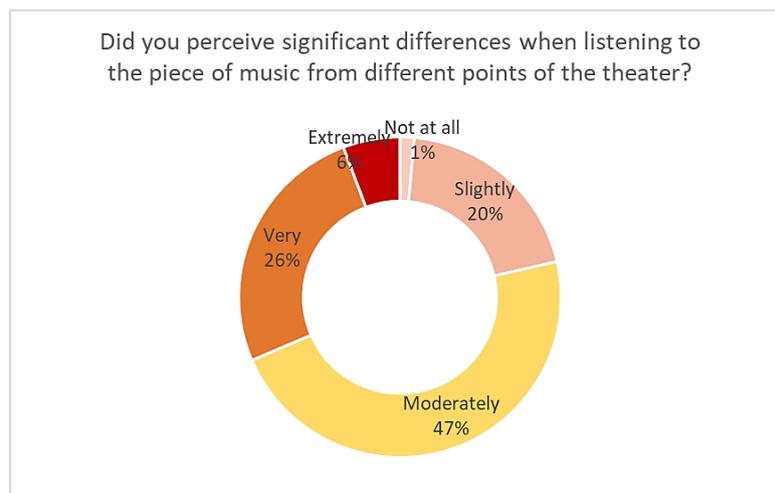


Figure 26 - Chart on the acoustic perception of audio video experience (General Public).

Table 2 shows that the great majority of the participants enjoyed the immersive experience which met the expectations of the greater part of the respondents. Particularly, it seems that the experience concerning the Berlin Konzerthaus was the most successful in terms of meeting participants' expectations.

	Not at all	Slightly	Moderately	Very	Extremely	NA
Konzerthaus (Berlin)	0	2	16	35	16	1
Teatro del Maggio Musicale Fiorentino (Florence)	0	6	15	37	9	3
Lviv National Academic Opera and Ballet Theatre (Lviv)	0	5	20	35	9	1

Table 2 - Evaluation of the audio-visual experience in the three theatres (General Public).

According to a great majority of the sample (66%), the possibility to listen to the piece of music from positions of the theatre which are usually difficult to access (e.g., the stage) or less affordable (e.g., the first rows) is an added value compared to the real experience. The majority of the sample also valued with at least "very", the extent to which being able of changing the number and typology of music instruments would provide an added value compared to the real experience (Figure 27). These results are quite in line with the evaluation given regarding the audio experience and suggest that giving the possibility to end users to modify the number of music instruments playing, and to select the type of instruments, would enhance the immersive experience tool.

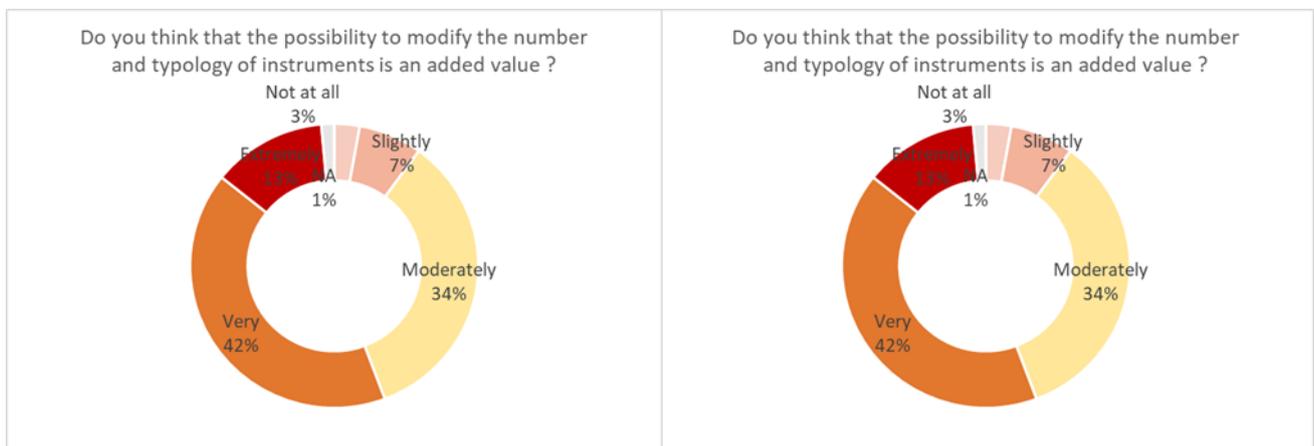


Figure 27 - Charts on the comparison between audio video experience and real experience (General Public).

Similarly, Figure 28 shows that the great majority of the sample thinks that being able to see the space in which the listening experience took place is an added value compared with the audio-only experience.

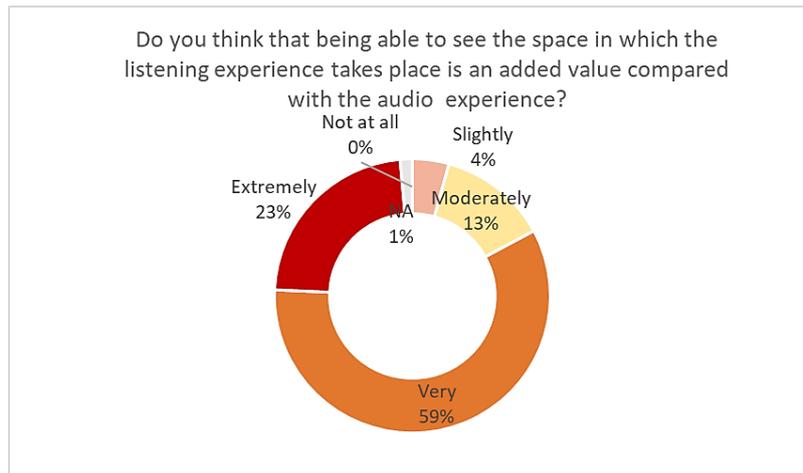


Figure 28 - Chart on the comparison between audio video experience and audio experience (General Public).

The immersive experience was mainly defined as “evocative” and “enjoyable”: instead, a limited number of participants defined the experience as relaxing (Figure 29). Furthermore, 17 participants out of 70, defined the experience as “slightly” or “moderately” interactive, suggesting that this aspect of the tool could be improved to meet end-users expectations.

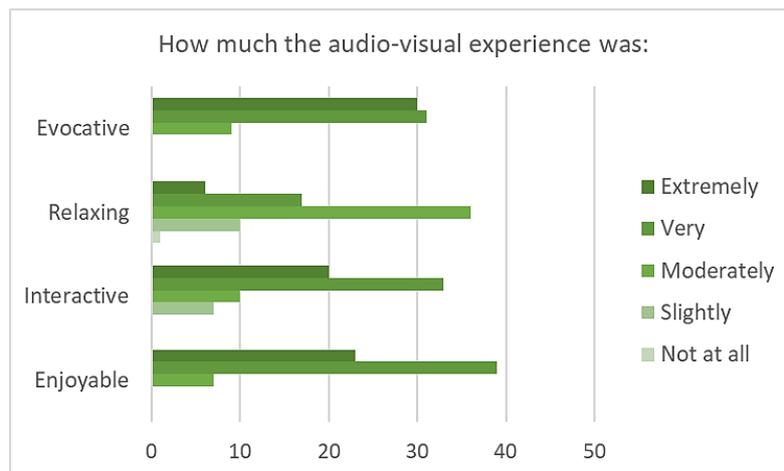


Figure 29 - Chart on the assessment of the audio video experience (General Public).

### Future developments

The following part of the questionnaire is devoted to assessing whether and how participants perceived differences among the immersive audio-visual experiences enjoyed in the three case studies. The Berlin Konzerthaus was selected by the majority of participants as the theatre where they had the most enjoyable audio-visual experience and the best audio experience. Notably, the Konzerthaus is also the preferred theatre in terms of architecture (Figure 30).

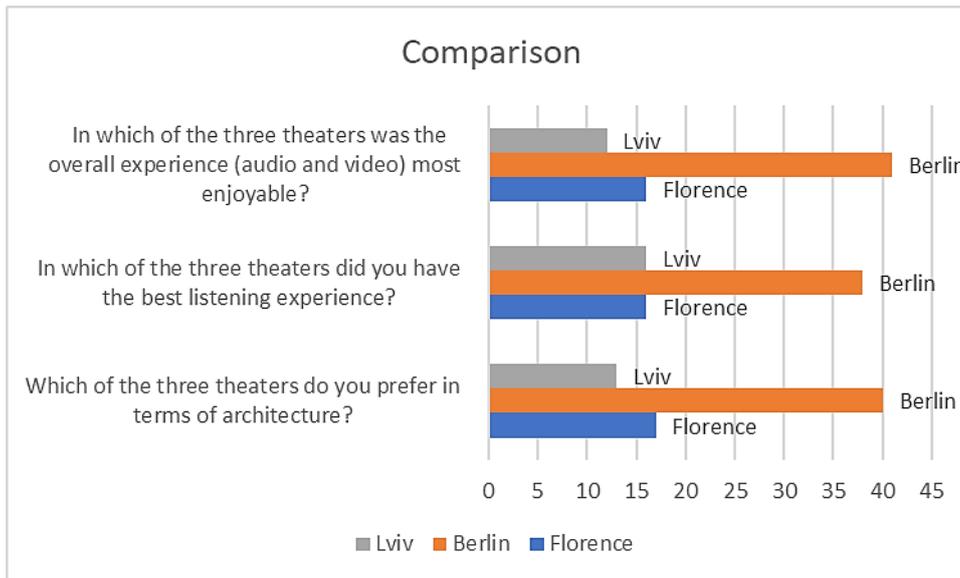


Figure 30 - Chart on the comparison between the three theatres (General Public).

The last section of the questionnaire focuses on future developments and aims to explore potential applications of the immersive tool. Notably, data show that the immersive experiences have the potential to attract new theatre audience. Indeed, 66% of the sample, mainly composed of young non-theatres goers, claimed that their willingness to go to the theatre had increased after the immersive experience. Also, according to a large portion of the sample (46%), the possibility to detect the acoustic differences in different positions of the theatre, given by the auralisation technique, could influence their choice in buying a particular seat to attend a theatre event in person (Figure 31).

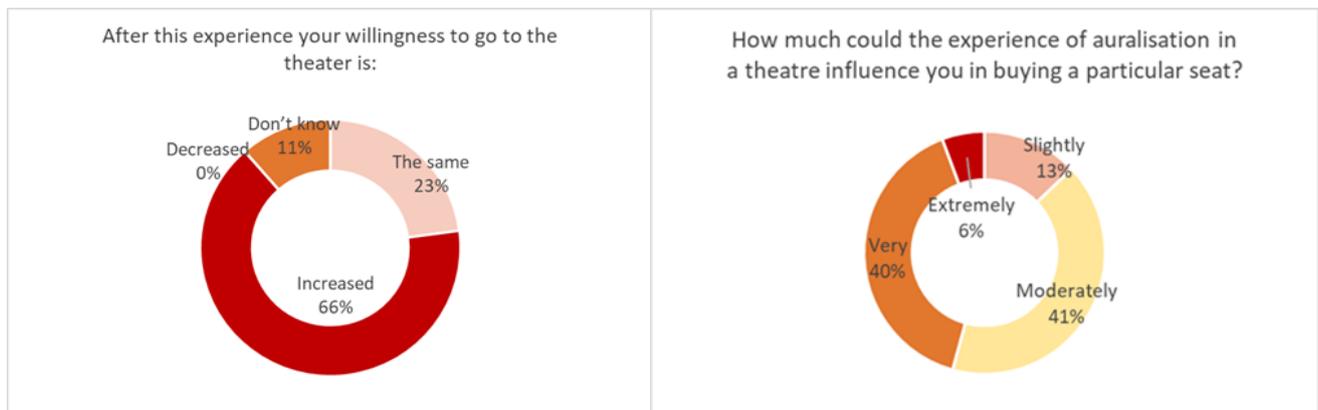


Figure 31 - Charts on potentialities of the immersive experience (General Public).

Results also demonstrate that the general public is extremely interested in having the kind of immersive experience like the one enjoyed at the laboratory from the comfort of their home. Specifically, 69% of the sample would like to have an immersive experience at home and 49% declared that would buy a ticket to enjoy it (Figure 32).

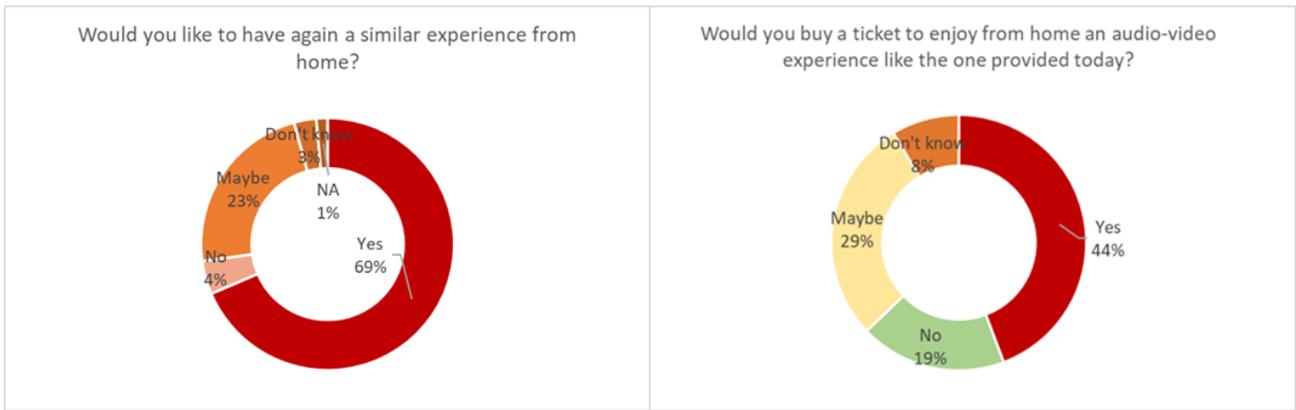


Figure 32 - Charts on the potential uses of the immersive experience (General Public).

Furthermore, Figure 33 shows that the sample identified the possibility of attending a performance when it is not possible to go (25 participants out of 70), or the theatre is far from home (22 out of 70) as significant potentialities of the audio-visual immersive experience and of the auralisation tool. Additionally, more than a quarter of participants think that the most relevant application of the immersive experience deals with giving the possibility to the audience to attend a performance from a place of the theatre which is usually difficult to access.

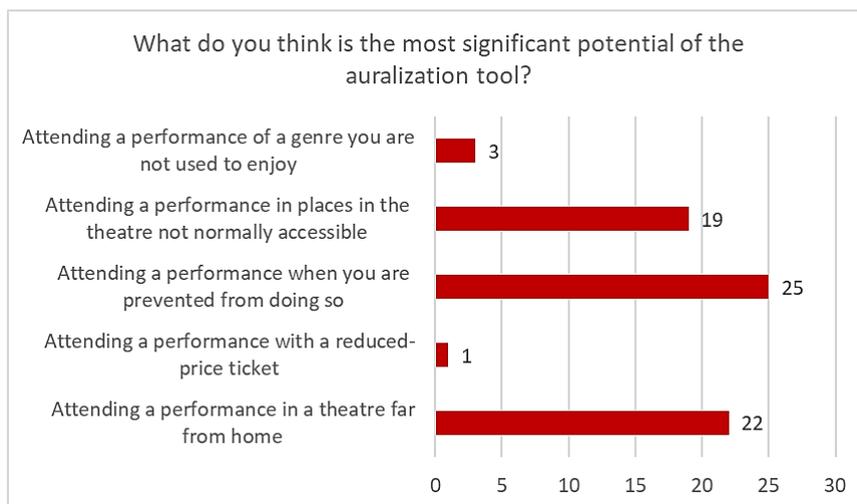


Figure 33 - Chart on the potential of the auralisation tool (General Public).

### 3.2.2 Results for Technicians

With reference to the sample group of technicians, a total of 41 participants were involved providing 41 completed questionnaires.

#### Demographic profile

The sample is equally distributed by gender and the majority of the respondents (63%) is in an age range between 26 and 40 years (Figure 34). 63% of the respondents has at least a high school diploma (Figure 34). Moreover, as regards their occupation, participants are mainly architecture or engineering students (42%), architects (24%) and designers (24%); whereas only 5% of the sample is made up of acoustic designers (Figure 35).

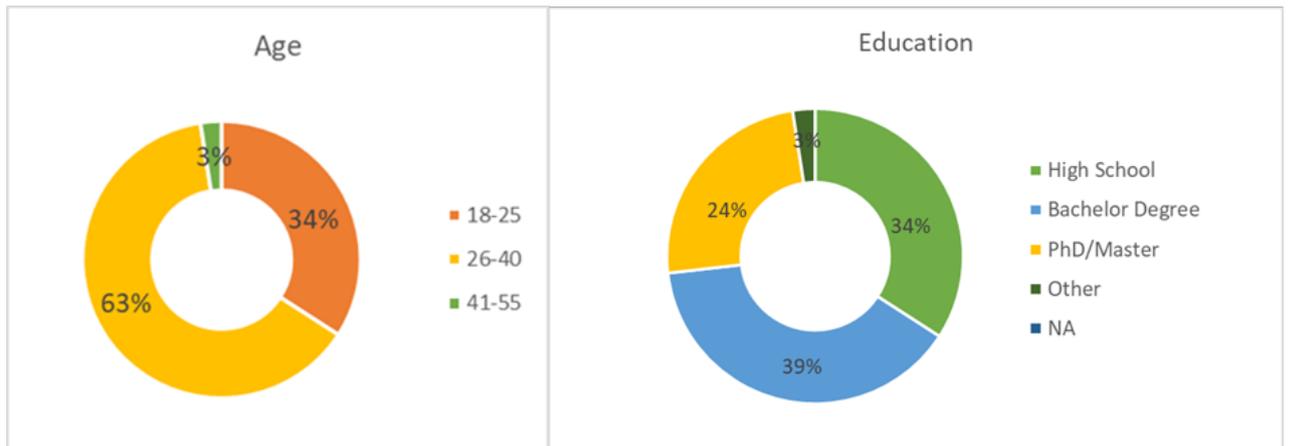


Figure 34- Charts on Age and Education (Technicians).

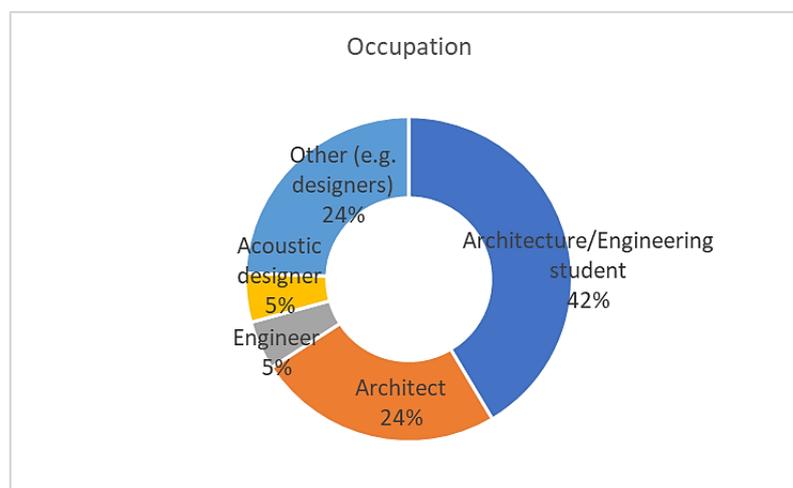


Figure 35 - Chart on Occupation (Technicians).

Concerning the professional experience that participating technicians have in the design or requalification, 7% of the sample has already dealt with acoustical and 5% with architectural design or requalification of a theatre (Figure 36).

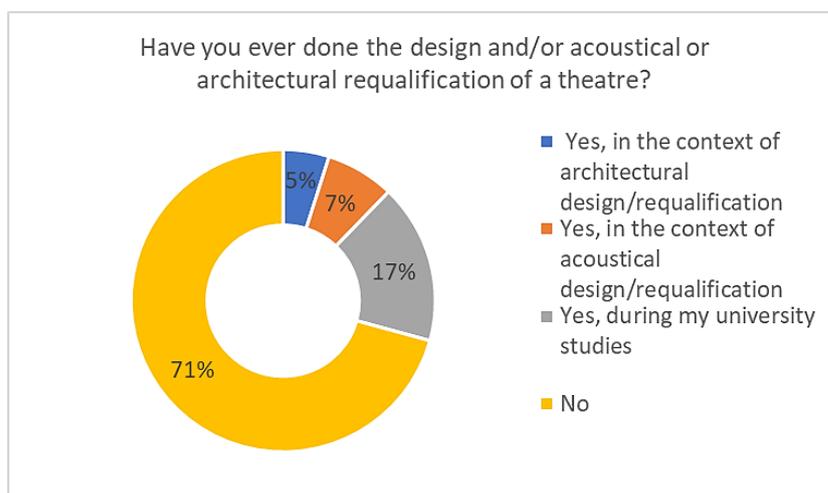


Figure 36 - Chart on professional background (Technicians).

**Theatre attendance habits**

63% of participants enjoys cultural events more than 6 times a year. However, Figure 37 also shows that the selected sample rarely attend live streaming or in-person music shows; specifically, only 6 respondents out of 41 attend live music shows in person more than 6 times a year.

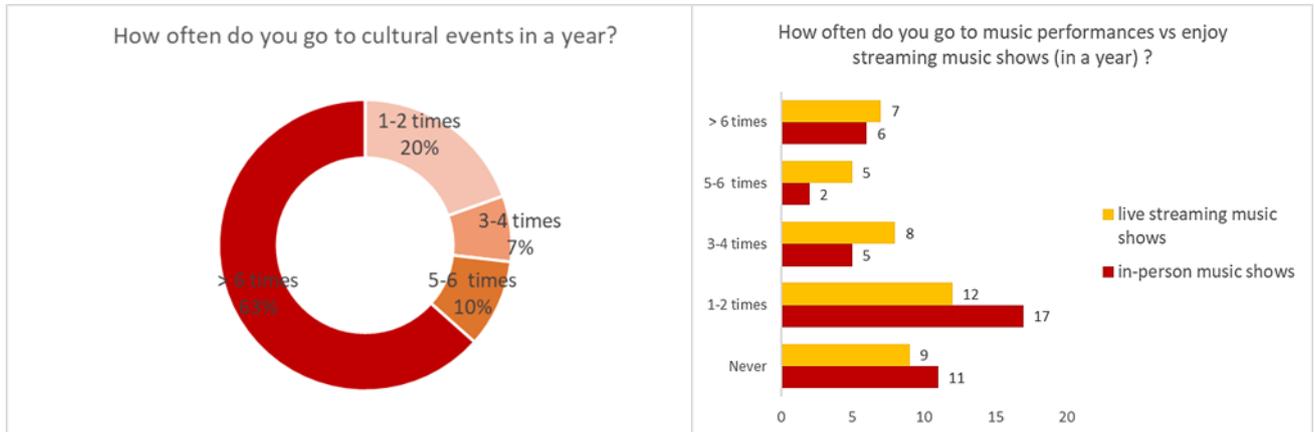


Figure 37 - Charts on theatre attendance habits (Technicians).

Generally, they prefer to attend modern and jazz concerts, musicals and classical plays (Figure 38).

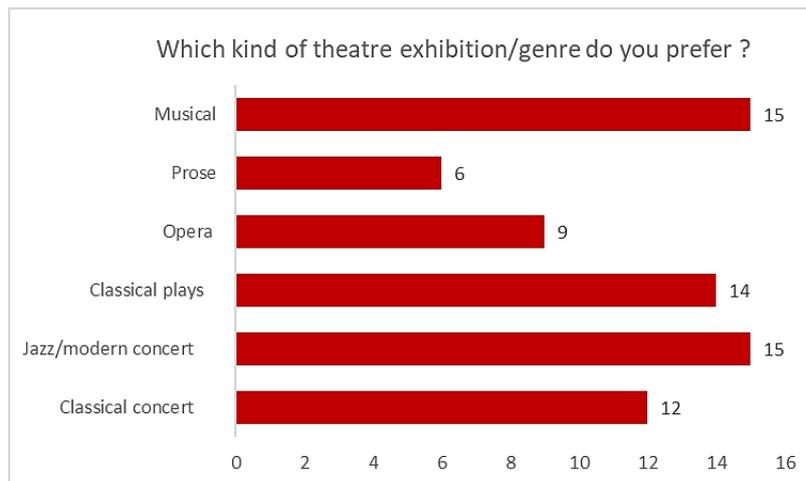


Figure 4 – Chart on preferred theatre genres (Technicians).

As presented in Table 3, half of the sample had already attended a live performance in the Teatro del Maggio Musicale Fiorentino, whereas a relevant portion of the sample had never attended a live performance in any of the three case studies which were reproduced by the AURA multisensory 3D models.

**Have you ever attended a live performance in one of these theatres?**

Konzerthaus (Berlin)	2
Teatro del Maggio Musicale Fiorentino (Florence)	22
Lviv National Academic Opera and Ballet Theatre (Lviv)	1
None of these	17

Table 3 - Theatre attendance in the three case studies (Technicians).

## Round tables

The results of the round tables carried out with technicians pointed out relevant benefits of the auralisation technique and of the innovative immersive tool.

Architects agreed that the immersive tool is a useful innovative tool for their profession, as it allows to evaluate the performance of materials not only aesthetically but also acoustically and allows a complete perception of space, and a complete understanding of proportional ratios of volumes. These benefits are also expected to lead to a reduction in the use of construction of physical prototypes (e.g., cardboards) which are currently used during the development process.

Concerning the utility of the tool for acoustic designers, the main benefit identified by participants deals with the acoustic simulation provided by the auralisation technique that allows to show design results to the clients for a better understanding and enjoyment of the designed spaces. Indeed, auralisation offers the possibility to “listen” to spaces before they are built and assess the effects of different design options, for example as regards the acoustic comfort of the specific space. In this way, auralisation provides great insight into the acoustic performance of any designed space.

For these reasons, technicians participating to the round table highlighted that the AURA immersive tool has great potential in both architectural and acoustic design check, providing an overall control of the designed environment. Furthermore, it is relevant to note that according to technician participants one of the main added values of the immersive tool compared to the traditionally used instruments, is the fact that it gives the possibility to test solutions and evaluate their effect (for end user) by simulating them in real time.

During the round table participants were also asked to suggest and discuss other potential applications of auralisation in their field. The following applications were suggested:

- To provide a virtual reality experience of urban parks and soundwalks,
- To offer alternative way to visit archaeological sites, also allowing a tour in a virtual reproduction of ancient sites and archaeological heritage,
- To give the possibility to join events in indoor and outdoor environments. (e.g., fairs, exhibitions, events in stadium),
- To check construction sites, particularly as regards points that are difficult to access,
- For the design of sound barriers.

Figure 39 summarises the main findings of the round table discussion.

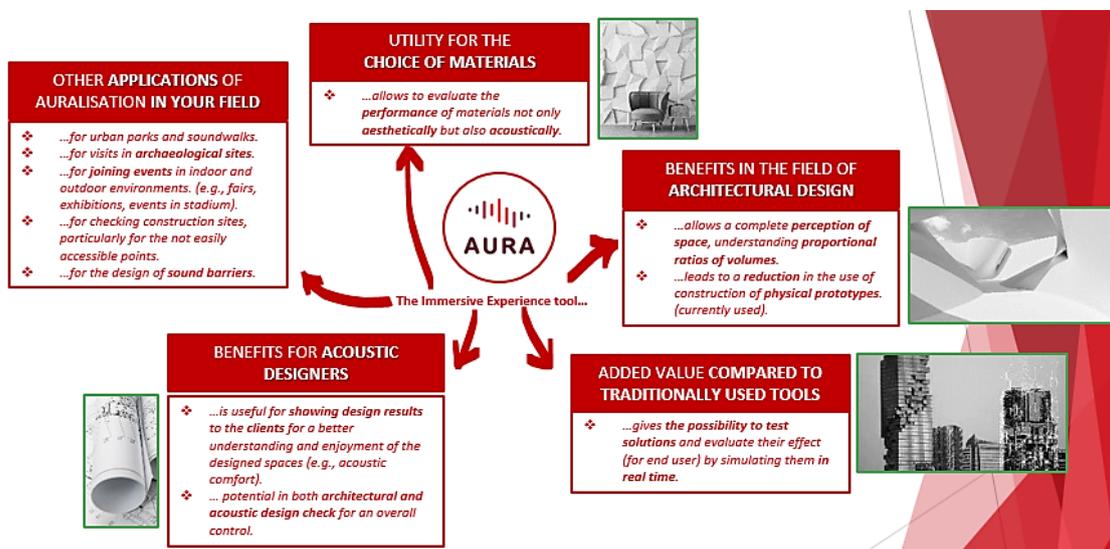


Figure 39 - Main results of round table discussions (Technicians).

### 3.2.3 Results for Experts

A total of 44 experts (musicians, actors, music students etc.) were involved and tested the immersive experiences, providing 44 completed questionnaires.

#### Demographic profile

As regards the gender distribution of participants, the number of male participants is slightly higher than the number of females (26 versus 18). The majority of the respondents (66%) is in an age range between 41 and 65 (Figure 40). Concerning education, almost 75% of the respondents has at least a bachelor's degree and 18% has completed post-graduate studies or a PhD (Figure 40). Half of the sample is composed by musicians (Figure 41) and pianists represent the largest group (Figure 42). 14% of the participants are singers, while the number of actors is less relevant (4% of the total).

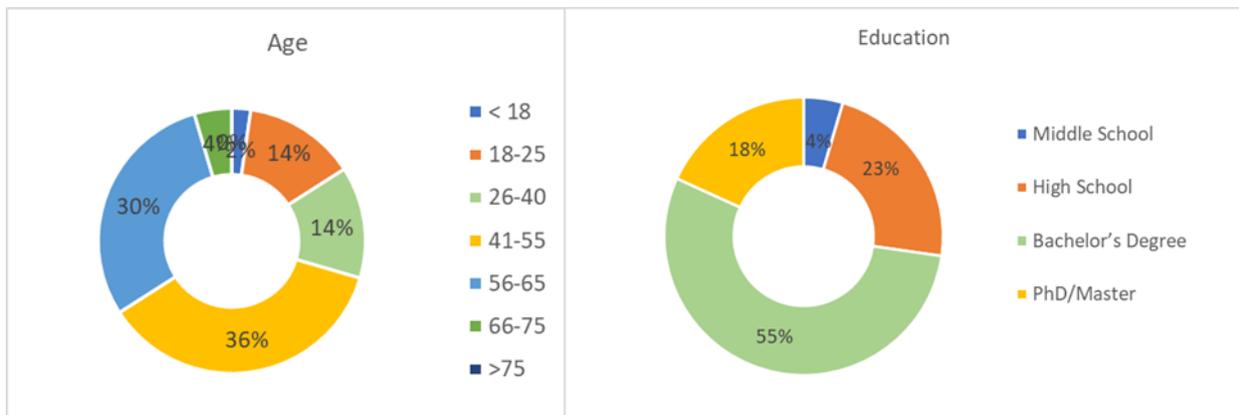


Figure 40 - Charts on age and education (Experts).

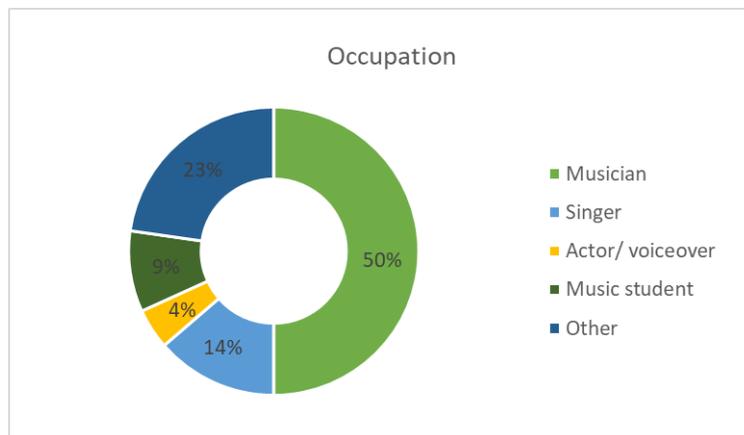


Figure 41 - Chart on Occupation (Experts).

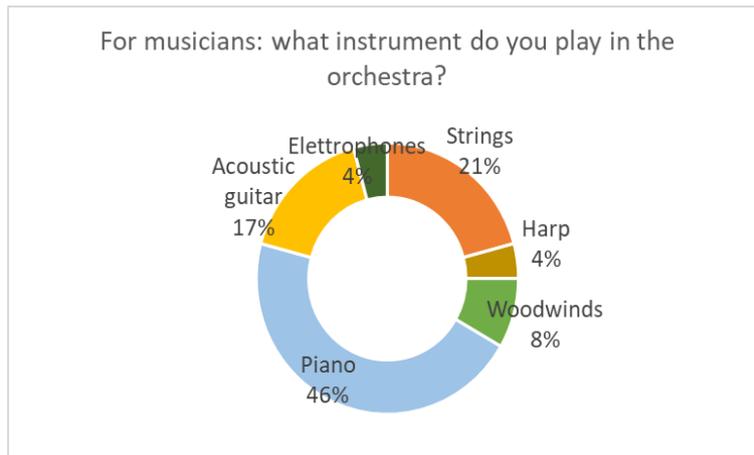


Figure 42 - Chart on music instruments (Experts).

It is also relevant to note that musicians which are part of the sample, mainly play classical concerts (Figure 43).

A great majority of the sample (70%) have many years of professional experience, and affirm that have been doing its job or studying music from more than 15 years.

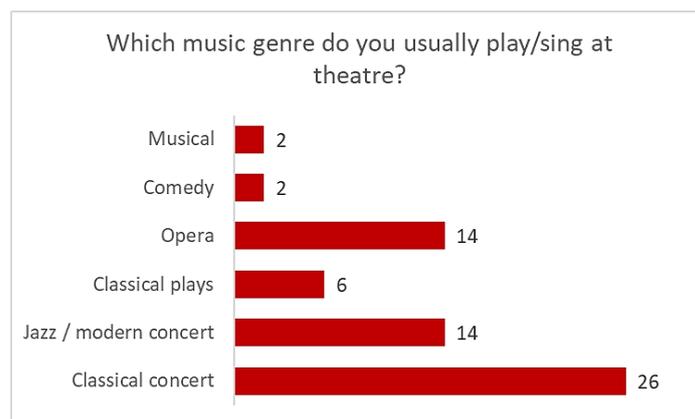


Figure 43 - Chart on played music genre (Experts).

### Theatre attendance habits

Not surprisingly, the expert group sample is composed of persons who are likely to participate to cultural events and are theatre-goers; 73% of the participants attend a cultural event more than 6 times a year and 61% enjoy music performances in person more than 6 times in a year (Figure ). However, it is important to note that almost half of the sample (46%) enjoys stream music shows less than 2 times in a year (or never) (Figure 44).

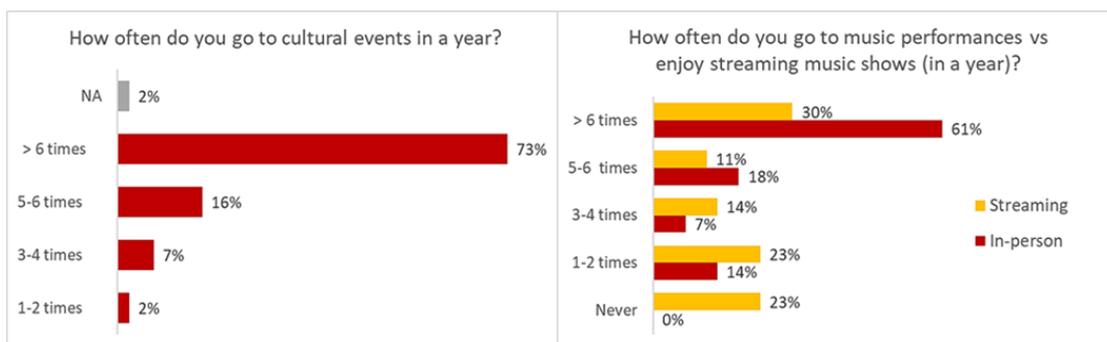


Figure 44 – Charts on cultural events and music shows attendance (Experts).

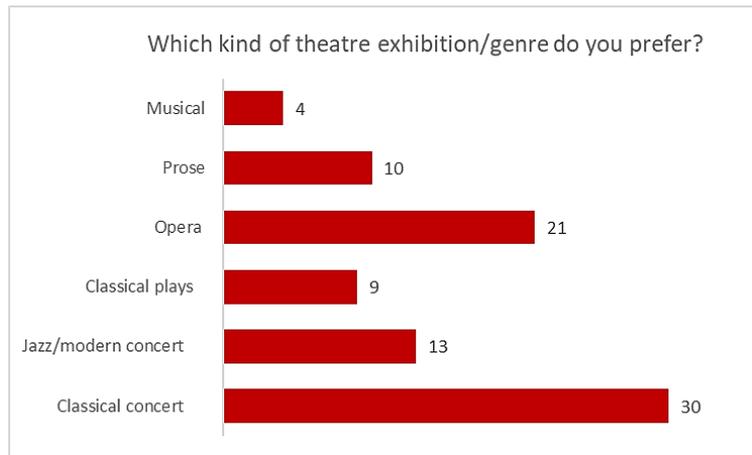


Figure 45 - Chart on preferred music genre (Experts).

Figure 45 shows that classical concerts and opera are the preferred typology of theatre exhibitions.

As reported in Table 4, a relevant number of participants from the experts' group (37 out of 44) has already attended a live performance at the Teatro del Maggio Musicale Fiorentino (in Florence) and 7 also know the Konzerthaus Berlin.

**Have you ever attended a live performance in one of these theatres?**

Konzerthaus (Berlin)	7
Teatro del Maggio Musicale Fiorentino (Florence)	37
Lviv National Academic Opera and Ballet Theatre (Lviv)	0
None of these	6

Table 4 -Theatre attendance in the three case studies (Experts).

**Round tables**

Round table discussions played a key role in the collection of useful insights and suggestions to technically improve the tools and maximize their benefits. Notably, no participants to round tables belonging to the experts' group had used audio-visual immersive tools before for work-related activities, whereas a limited number had already experienced virtual reality for metaverse and virtual reality games.

As regards the functionalities of the tool and its use for work-related activities, experts agreed that the possibility to listen to the music piece from different points of the theatre and to appreciate acoustic differences is particularly useful to evaluate the spatial response of a music performance and to identify the best points on stage for actors' voice output. Musicians also pointed out that the use of the immersive tool would help them to test in advance the environment and evaluate the acoustic response of the theatre or other spaces (e.g., a church) before the performance. Specifically, participants highlight that the auralised 3D models could be particularly useful as regards recently built theatres whose acoustic is not well known by artists.

These aspects are also expected to be appreciated by musicians playing chamber music and playing in symphony orchestra as well as (potentially) by conductors, who can have a valid support helping them to place instruments before playing or rehearsal in the actual performance spaces.

However, most of participants to round tables pointed out that the potentialities of the tool for their professional activities as performers are still low, especially considering the current technological development. In particular, many participants identified the need to enhance the AURA 3D models in terms of acoustic performance with technical improvements to provide a better reproduction of the sound environment of a real space and of its perception. As an illustration, it has been underlined that auralisation needs to be faithful both in terms of signal amplitude and reverberation at different positions.

Notably, while enjoying the immersive experience some participants expressed their resistance to the use of the tool especially regarding i) future scenarios offering virtual reality as the only alternative to the immersive nature of live performance and ii) the use as an alternative rather than a complement for their activities as regards rehearsals of live performance.

On the other hand, according to round table participants, immersive experiences are useful for didactic purposes and as marketing tools with great potential to promote live performances.

A special emphasis was given to the advantages provided by the possibility to activate and deactivate different music instruments, experienced by participants during the audio experience. Specifically, the following benefits and useful applications considered an added value compared to the real experience, were identified by several participants:

- Use of the activation/deactivation function when practicing, especially for musicians playing in an instrumental ensemble,
- Use for didactic purposes and ear training and to facilitate the study and memorization of a music piece,
- Use of the function by music composers to calibrate different sounds and music instruments.

Beyond the significant acknowledged potentialities concerning didactic applications, several participants also agreed that generally AURA immersive experiences are the kind of technological applications able to promote theatre and musical performances and to attract new audiences. Specifically, young people are expected to gain the most from this type of virtual experience and gradually get passionate about “unfamiliar places” such as theatres (see Figure 46).

Furthermore, it is important to note that immersive experiences in virtual reality are considered a useful instrument to give people who cannot go to theatres (e.g., patients in hospitals), or live far from the performance site, the possibility to enjoy a theatre performance.

Several potentialities as marketing tool have been also identified. Indeed, the integration of auralisation in virtual reality can give theatre audience the possibility to hear online what the acoustic result might be from a specific seat. For this reason, the tool has significant potential for a “booking seats” application for theatres. Additionally, an application to create trailers for theatre and performance promotion was also suggested.

Other interesting points which demonstrate the entertainment value of the tool emerged from the discussions. First, some participants claimed that the immersive experience could be particularly effective to enjoy shows with a limited duration. Additionally, another participant suggested that “instruments of this kind, instead of being used to enjoy a traditional theatre or music experience, can open up new avenues for completely new

performances in a virtual environment, specifically designed to make the most of these innovative technological application”. In other words, immersive technologies are also expected to prompt new performance practices.

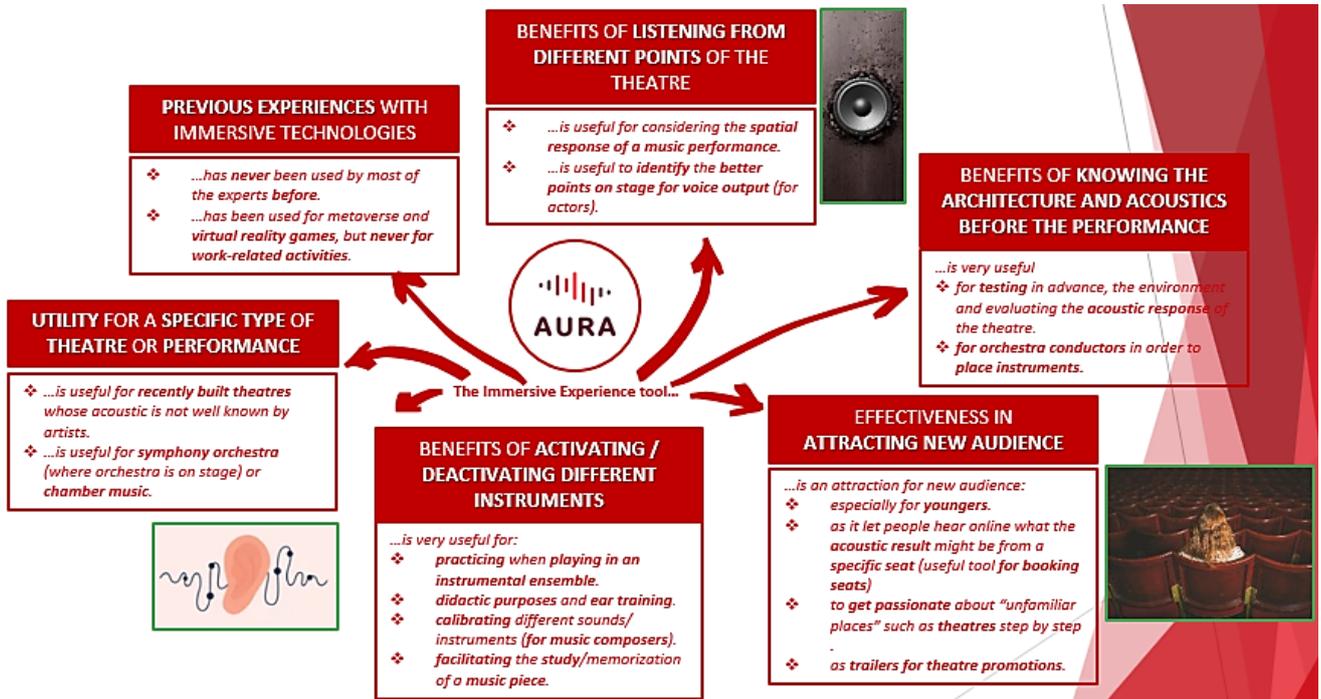


Figure 46 - Results of round table discussions (Experts).

## 4. Conclusions and possible insights

Streaming and virtual reality technologies applications have recently become popular aspects of cultural events and theatres performances consumption and have experienced a significant increase in engagement in the wake of the Covid-19 pandemic.

Against this background, the aim of this report is to assess audience experience in innovative auralised 3D models developed by the AURA project. In order to bring a variety of perspectives and evaluate how distinct typologies of audience enjoy immersive experience, three groups of participants (general public, technicians and experts) were involved to prove the AURA immersive experiences and asked to fill in a questionnaire tailored to their sample group peculiarities and specific professional backgrounds. Round tables discussions were also organised with technicians and experts to collect their feedbacks and suggestions on future developments and potential applications of the immersive tools and, more generally, of the auralisation technique.

Thanks to the organised sessions at the Laboratory of Extended Reality of the Department of Architecture at the University of Florence, 155 participants enjoyed the immersive experiences designed and conducted by Vie en.ro.se Ingegneria project partner, particularly the virtual reality experience which couples auralisation with visual virtual reality.

Results have demonstrated that virtual immersive theatre experiences provide a great tool for audience to enjoy music performance from the comfort of their own homes. Indeed, the great majority of the general public sample, mainly composed of young people and non-theatre goers, mainly defines the AURA immersive experience as “evocative” and “enjoyable” and expresses the desire to have a similar experience at home. Specifically, enjoying the possibility to listen to the piece of music from points of the theatre which are usually difficult to access (e.g., the stage) or less affordable (e.g., the front row) is generally considered an added value compared to the real experience.

The sample also identifies the possibility of attending a performance when it is not possible to go (during COVID pandemic restrictions or for patients in hospital), or the theatre is far from home as significant potential of the auralisation tool.

Round table discussions have shed light on the diversity of potential applications for auralised 3d models encompassing the integration of auralisation in architect workflows, application as marketing tools for theatres (e.g., an application to choose online the seat to book), teaching instruments, and their use for new performance practices. Limitations have been also pointed out.

Specifically, great potentialities have been highlighted as regards the use of auralised 3d models by architects and acoustic designers. Indeed, according to participants these models are useful in the context of the design process to test ideas (e.g., use of specific materials) and communicate with clients since they enable them to have a direct listening experience of the space before it is built. The spatiality offered by the immersive tool through the innovative integration of visual and acoustic aspects is a great opportunity to know the design space in advance.

Some limitations linked to applications in the field of music performances have been identified. A gap still exists between the real experience/reality and the immersive 3d simulate environment. While the spatial accuracy for a client of an acoustic designer or a non-attentive listeners who is choosing a seat in a theatre may be not be perfect, auralisation is required to be as accurate as possible when presented to a musician who can potentially use the tool to know the architecture and acoustics of a theatre before the performance (see also They et al. 2019). Additionally, several participants belonging to the General Public group defined the experience as “slightly” or “moderately” interactive. Thus, the interactivity of the tool could be improved to meet end-users expectations.

On the other hand, participants point out the relevant utility of the tool i) for didactic purposes, especially recognizing the benefits provided by the possibility of activating / deactivating different instruments and listening to their acoustic performance from different points of the space and ii) as innovative marketing tool to promote live theatre and music performances.

Taking into consideration both the benefits and potentialities of the tool and the highlighted current limitations is crucial to enhance the immersive tools and their applications, in order to make auralisation of cultural places accessible to future developments and uses and maximise its benefits.

## 5. References

Baker T. *Stop re-inventing the wheel: a guide to what we already know about developing audiences for classical music*. Association of British orchestras, 2000.

Dilokkunanant K. "Strategies for classical music audiences: an exploration of existing practices used by western European art music organisations." DMA (Doctor of Musical Arts) thesis, University of Iowa, 2019.

They D., Boccara V., Katz B. F., Auralization uses in acoustical design: A survey study of acoustical consultants. *The Journal of the Acoustical Society of America*, 145(6), 3446-3456, 2019. DOI 10.1121/1.5110711

[www.theaudienceagency.org](http://www.theaudienceagency.org)

## 6. Appendix I

### QUESTIONNAIRE FOR GENERAL PUBLIC

Welcome to DIDALab!

This experience will take you inside three important opera and music theatres in Berlin, Florence and Lviv. You will be able to observe the architecture of the theatres from three different historical periods, sit in different seats and appreciate different points of view. You will be able to dive into a musical performance of wind, percussion, and string instruments. As a piece of music, we chose a composition by Claude Debussy: the 4th part "Golliwogg's Cakewalk" from "Children's Corner".

All this will be possible thanks to modern technologies, which have become familiar in the enjoyment of our cultural heritage. Theatrical and musical performances are 'immersive' by nature, and the step from physical to virtual experience is now a short one. Using the technique of auralisation, i.e., the creation of virtual soundscapes using 3D models, the participant surrenders themselves to a concert or opera in a virtual environment where he or she can move around the space and experience how the architecture influences the sound.

With the AURA project, which started in January 2021, the opera and music theatres of Berlin, Florence and Lviv, supported by technology and marketing partners, are committed to exploiting the potential that auralisation offers to musical arts and performances. Three case studies will show auralisation experiences with 3D models of theatres, producing new and exciting ways to experience music.

You will now be asked to fill in a questionnaire, promoted by the AURA project and administered by Vie en.ro.se Ingegneria. Why are your answers useful?

- 1) To get to know the **habits and preferences** of participants in **classical music performances**
- 2) To receive your **opinion** on the immersive experience of **auralisation**.

The questionnaire is divided into sections, and you will be able to answer the relevant questions as soon as you receive instructions from the researchers in the room:

#### A. PERSONAL INFORMATION

#### B. HABITS AND BEHAVIORS RELATED TO FRUITION

#### C. AUDIO EXPERIENCE

#### D. AUDIO-VISUAL EXPERIENCE

#### E. COMPARISON BETWEEN THE EXPERIENCES

#### F. FUTURE DEVELOPMENTS

Please answer all questions in the order they are listed, following the indications provided. This survey collects your data anonymously. We inform you that the processing will in any case be confidential and the subsequent publication of the results will be carried out in order to ensure the non-recognition of the responses. You can now proceed to fill in sections A and B to let us know who you are and tell us about your theatre-going habits!

## A. PERSONAL INFORMATION

1. Age:

- <18    18-25    26-40    41-55    56-65    66-75    >75

2. Gender:

- Female    Male    Non binary

3. Education:

- Primary school    Middle School    High School    Bachelor's Degree    PhD/Master  
 Other (\_\_\_\_\_)

4. Occupation: \_\_\_\_\_

5. Nationality: \_\_\_\_\_

## B. HABITS AND BEHAVIORS RELATED TO FRUITION

6. How often do you go to cultural events (museum, theatre, cinema) in a year (on average)? *(Please, select just one answer)*

- Never    1-2 times    3-4 times    5-6 times    > 6 times

7. How often do you go to certain types of music performances (opera, ballet/dance, musical shows, classic music concerts, popular music concerts) in a year (on average)? *(Please, select just one answer)*

- Never    1-2 times    3-4 times    5-6 times    > 6 times

8. Which kind of theatre exhibition/genre do you prefer when you go to the theatre? *(Multiple choice)*

- Classical concert    Jazz / modern concert    Opera    Prose    Musical

9. What are your reasons for going to music theatre? *(Multiple choice)*

- uniqueness of the performance    listening to a richer, louder, more real sound  
 spending a special evening in the company of others  
 a 'live' event has a great visual impact  
 it is an opportunity to spend time for myself  
 for learning    I do not go to the theatre/I do not know

10. Indicate to which of these kinds of shows you would associate the following statuses. You can associate several shows with the same status. *(Multiple choice)*

<b>Status</b>	Classical concert	Jazz/ modern concert	Classical plays	Opera	Prose	Musical
<b>Affordable</b>						
<b>Wide selection</b>						
<b>Better in the theatre than on TV</b>						
<b>For entertainment</b>						
<b>It makes you think</b>						

11. How do you usually enjoy music? *(Please, select just one answer)*

- Listening to the radio   
 Listening to streaming music   
 Playing a musical instrument  
 I go to the theatre   
 I listen to music on TV

12. How often do you enjoy **stream music** shows in a year (on average)? *(Please, select just one answer)*

- Never   
 1-2 times   
 3-4 times   
 5-6 times   
 > 6 times

13. Have you ever attended a live performance in one of these theatres?

- Konzerthaus (Berlin)   
 Teatro del Maggio Musicale Fiorentino (Florence)  
 Lviv National Academic Opera and Ballet Theatre (Lviv)   
 None

14. How open would you consider yourself to be to new technical developments?

- Not at all   
 Slightly   
 Moderately   
 Very   
 Very much

15. Which technical devices do you own?

- Smartphone   
 tablet   
 VR headset

### C. AUDIO EXPERIENCE

16. Please rate the audio experience you have just taken part in *(One answer for each question)*

<b>Did you perceive significant differences when listening to the piece of music at different points of the theatre?</b>	Not at all	Slightly	Moderately	Very	Very much
<b>Based on your experience or knowledge, how well do you</b>	Not at all	Slightly	Moderately	Very	Very much

<b>think the audio experience you have just had meets your expectations?</b>					
<b>Do you think that listening in points that are more difficult to access (e.g., on the stage or in the front row) is an added value to the real experience?</b>	Not at all	Slightly	Moderately	Very	Very much
<b>Do you think that the possibility of changing the number and type of instruments in the orchestra is an added value compared to the real experience?</b>	Not at all	Slightly	Moderately	Very	Very much

#### D. AUDIO-VISUAL EXPERIENCE

17. Did you perceive significant differences when listening to the piece of music from different points of the theatre? *(One answer for each theatre)*

Not at all    Slightly    Moderately    Very    Very much

18. To what extent does the full experience (audio and video) meet your expectations? *(One answer for each theatre)*

<b>Konzerthaus (Berlin)</b>	Not at all	Slightly	Moderately	Very	Very much
<b>Teatro del Maggio Musicale Fiorentino (Florence)</b>	Not at all	Slightly	Moderately	Very	Very much
<b>Lviv National Academic Opera and Ballet Theatre (Lviv)</b>	Not at all	Slightly	Moderately	Very	Very much

19. Do you think that the listening from the points of the theatre that are difficult to access (e.g., stage or the front row) offer an added value compared to the real experience? *(Please, select just one answer)*

Not at all    A little    Moderately    Very    Extremely

20. Do you think that the possibility to modify the number and typology of instruments in the orchestra is an added value compared to the real experience? *(Please, select just one answer)*

Not at all    A little    Moderately    Very    Extremely

21. Do you think that being able to see the space in which the listening experience takes place is an added value compared with the audio-only experience? *(Please, select just one answer)*

Not at all    A little    Moderately    Very    Extremely

22. Indicate how much the audio-visual experience was...

<b>Enjoyable</b>	Not at all	Slightly	Moderately	Very	Very much
<b>Interactive</b>	Not at all	Slightly	Moderately	Very	Very much
<b>Relaxing</b>	Not at all	Slightly	Moderately	Very	Very much
<b>Evocative</b>	Not at all	Slightly	Moderately	Very	Very much

## E. COMPARISON BETWEEN THE EXPERIENCES

23. Which of the three theatres do you prefer in terms of architecture? *(Please, select just one answer)*

- Florence    Berlin    Lviv

24. In which of the three theatres did you have the best listening experience? *(Please, select just one answer)*

- Florence    Berlin    Lviv

25. In which of the three theatres was the overall experience (audio and video) most enjoyable? *(Please, select just one answer)*

- Florence    Berlin    Lviv    No preference

## F. FUTURE DEVELOPMENTS

26. After this experience your willingness to go to the theatre is: *(Please, select just one answer)*

- The same    Increased    Decreased    Don't know

27. How much could the experience of auralisation in a theatre influence you in buying a particular seat? *(Please, select just one answer)*

- Not at all    Slightly    Moderately    Very    Very much

28. Would you like to have again a similar experience from home? *(Please, select just one answer)*

- Yes    No    Maybe    Don't know

29. Would you buy a ticket for a play or a concert as if they were played in a specific theatre of your choice, so that you can enjoy them directly from your home through an audio/video experience like the one provided today? *(Please, select just one answer)*

- Yes    No    Maybe    Don't know

30. What do you think is the most significant potential of the auralisation tool? *(Please, select just one answer)*

- Attending a performance in a theatre far from home
- Attending a performance with a reduced-price ticket
- Attending a performance when you are prevented from doing so (e.g., medical emergency restrictions or personal restrictions)
- Attending a performance in places in the theatre not normally accessible (e.g., on stage)
- Attending a performance of a genre you are not used to enjoying



## QUESTIONNAIRE FOR TECHNICIANS

Welcome to DIDALab!

This experience will take you inside three important opera and music theatres in Berlin, Florence and Lviv. You will be able to observe the architecture of the theatres from three different historical periods, sit in different seats and appreciate different points of view. You will be able to dive into a musical performance of wind, percussion, and string instruments. As a piece of music, we chose a composition by Claude Debussy: the 4th part "Golliwogg's Cakewalk" from "Children's Corner".

All this will be possible thanks to modern technologies, which have become familiar in the enjoyment of our cultural heritage. Theatrical and musical performances are 'immersive' by nature, and the step from physical to virtual experience is now a short one. Using the technique of auralisation, i.e., the creation of virtual soundscapes using 3D models, the participant surrenders themselves to a concert or opera in a virtual environment where he or she can move around the space and experience how the architecture influences the sound.

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We ask you to fill in the following questionnaire, promoted by the AURA project and administered by our partner Vie en.ro.se Ingegneria, in order to find out about your personal **habits** and **preferences**.

At the end of the interactive experience, you will participate in a **round table discussion** with other experts in the design of enclosed spaces, with whom you will be able to discuss the pros and cons of auralisation and its potential use for engineers, architects, acoustic designers, and university students in this field. Your opinion may provide us interesting insights for future research developments.

Please answer all questions in the order they are listed, following the indications provided. This survey collects your data anonymously.

We inform you that the processing will in any case be confidential and the subsequent publication of the results will be carried out in order to ensure the non-recognition of the responses.

### A. PERSONAL INFORMATION

1. Age:

<18    18-25    26-40    41-55    56-65    66-75    >75

2. Gender:

Female    Male    Non binary

3. Education:

High School    Bachelor's Degree    PhD/Master    Other (\_\_\_\_\_)

4. Occupation:

Architecture/Engineering student    Architect    Engineer

Acoustic designer    Other (\_\_\_\_\_)

5. Nationality: \_\_\_\_\_

### B. HABITS RELATED TO FRUITION AND PROFESSIONAL EXPERIENCE

6. How often do you go to cultural events (museum, theatre, cinema) in a year (on average)? *(Please, select just one answer)*
- Never    1-2 times    3-4 times    5-6 times    > 6 times
7. How often do you go to certain types of music performances (opera, ballet/dance, musical shows, classic music concerts, popular music concerts) in a year (on average)? *(Please, select just one answer)*
- Never    1-2 times    3-4 times    5-6 times    > 6 times
8. Which kind of theatre exhibition/genre do you prefer when you go to the theatre? *(Multiple choice)*
- Classical concert    Jazz/modern concert    Classical plays    Opera
- Prose    Musical
9. How often do you enjoy **stream music** shows in a year (on average)? *(Please, select just one answer)*
- Never    1-2 times    3-4 times    5-6 times    > 6 times
10. Have you ever attended a live performance in one of these theatres?
- Konzerthaus (Berlin)    Teatro del Maggio Musicale Fiorentino (Florence)
- Lviv National Academic Opera and Ballet Theatre (Lviv)    None
11. Have you ever done the design and/or acoustical or architectural requalification of a theatre? *(Please, select just one answer)*
- Yes, in the context of architectural design/requalification
- Yes, in the context of acoustical design/requalification
- Yes, during my university studies
- No



## QUESTIONNAIRE FOR EXPERTS

Welcome to DIDALab!

This experience will take you inside three important opera and music theatres in Berlin, Florence and Lviv. You will be able to observe the architecture of the theatres from three different historical periods, sit in different seats and appreciate different points of view. You will be able to dive into a musical performance of wind, percussion, and string instruments. As a piece of music, we chose a composition by Claude Debussy: the 4th part "Golliwogg's Cakewalk" from "Children's Corner".

All this will be possible thanks to modern technologies, which have become familiar in the enjoyment of our cultural heritage. Theatrical and musical performances are 'immersive' by nature, and the step from physical to virtual experience is now a short one. Using the technique of auralisation, i.e., the creation of virtual soundscapes using 3D models, the participant surrenders themselves to a concert or opera in a virtual environment where he or she can move around the space and experience how the architecture influences the sound.

With the AURA project, which started in January 2021, the opera and music theatres of Berlin, Florence and Lviv, supported by technology and marketing partners, are committed to exploiting the potential that auralisation offers to musical arts and performances. Three case studies will show auralisation experiences with 3D models of theatres, producing new and exciting ways to experience music.

We ask you to fill in the following questionnaire, promoted by the AURA project and administered by our partner Vie en.ro.se Ingegneria, in order to find out about your personal **habits** and **preferences**.

At the end of the interactive experience, you will participate in a **round table discussion** with other experts in performing musical and/or drama shows, with whom you will be able to discuss the pros and cons of auralisation and its potential use for musicians, singers, conductors, actors, and students in this field. Your opinion may provide us interesting insights for future research developments.

Please answer all questions in the order they are listed, following the indications provided. This survey collects your data anonymously.

We inform you that the processing will in any case be confidential and the subsequent publication of the results will be carried out in order to ensure the non-recognition of the responses.

### A. PERSONAL INFORMATION

1. Age:

<18    18-25    26-40    41-55    56-65    66-75    >75

2. Gender:

Female    Male    Non binary

3. Education:

Primary school    Middle School    High School    Bachelor's Degree    PhD/Master

4. Occupation

Musician    Singer    Orchestra director    Actor/ voiceover    Music student

Theatre subscriber    Other (*Please, specify*) \_\_\_\_\_

5. Nationality: \_\_\_\_\_

## B. HABITS RELATED TO FRUITION AND PROFESSIONAL EXPERIENCE

6. How often do you go to cultural events (museum, theatre, cinema) in a year (on average)? *(Please, select just one answer)*

Never  1-2 times  3-4 times  5-6 times  > 6 times

7. How often do you go to certain types of music performances (opera, ballet/dance, musical shows, classic music concerts, popular music concerts) in a year (on average)? *(Please, select just one answer)*

Never  1-2 times  3-4 times  5-6 times  > 6 times

8. Which kind of theatre exhibition/genre do you prefer when you go to the theatre? *(Multiple choice)*

Classical concert  Jazz / modern concert  Opera  Prose  Musical

9. How often do you enjoy **stream music** shows in a year (on average)? *(Please, select just one answer)*

Never  1-2 times  3-4 times  5-6 times  > 6 times

10. Have you ever attended a live performance in one of these theatres?

Konzerthaus (Berlin)  Teatro del Maggio Musicale Fiorentino (Florence)

Lviv National Academic Opera and Ballet Theatre (Lviv)  None

11. How many years have you been doing your job/studying music/visiting theatres regularly? *(Please, select just one answer)*

0-2  2-5  5-10  10-15  > 15

12. For musicians: what instrument do you play in the orchestra?

Strings *(Please, specify \_\_\_\_\_)*

Harp  Woodwinds *(Please, specify \_\_\_\_\_)*

Brasses *(Please, specify \_\_\_\_\_)*

Percussion *(Please, specify \_\_\_\_\_)*  Piano

Acoustic guitar  Elettrophones *(Please, specify \_\_\_\_\_)*

13. For musicians/singers: Which music genre do you usually play/sing at theatre? *(Multiple choice)*

Classical concert  Jazz / modern concert  Classical plays  Opera

Comedy  Musical

14. For actors/double actors: Which genre do you usually perform in the theatre? *(Multiple choice)*

Classical plays  Comedy  Musical



## 7. Appendix II

### THE AUDIO INTERACTIVE GAME

The technical supervisor provides a link to the users for having access to the online quiz to be filled-in in real-time on mobile phones during the audio experience.

The technical supervisor provides stereo headphones to each of the users for the listening of auralised audio tracks of one of the theatres (e.g., TOF). The audio track, provided by HTW, consists of different instruments playing inside the theatre in different listening positions, according to the following structure:

- Listening only to the clarinet playing from the first row (maximum 10 seconds);
- Listening only to the harp playing from the first row (maximum 10 seconds);
- Listening to the violine, violoncello and double bass playing from the first row (maximum 10 seconds);
- Listening to the Flute, oboe and trumpet playing from the first row (maximum 10 seconds);
- Listening to the whole orchestra from the balcony (maximum 10 seconds);
- Listening to the whole orchestra from the stage (maximum 10 seconds).

The following scenarios are played, and the correspondent question displayed on the screens of the users:

#### 1. **Listening only to the clarinet playing from the first row**

QUIZ: *What is the instrument playing?*

OPTIONS:

Clarinet    Violoncello    Drum

#### 2. **Listening only to the harp playing from the first row**

QUIZ: *What is the instrument playing?*

OPTIONS:

Double bass    Harp    Violine

#### 3. **Listening to the violine, violoncello and double bass playing from the first row**

QUIZ: *What kind of instruments are playing?*

OPTIONS:

stringed instruments    wind instruments    percussion instruments

#### 4. **Listening to the Flute, oboe and trumpet playing from the first row**

QUIZ: *What kind of instruments are playing?*

OPTIONS:

stringed instruments    wind instruments    percussion instruments

#### 5. **Listening to the whole orchestra from the balcony**

QUIZ: *How far are you from the orchestra playing?*

OPTIONS:

Very far    Far    Neither far nor close    Close    Very close

#### 6. **Listening to the whole orchestra from the stage**

QUIZ: *How far are you from the orchestra playing?*

OPTIONS:

Very far    Far    Neither far nor close    Close    Very close

#### 7. **Concerning the Audio Experience**

*QUIZ: Have you learnt something new after this experience?*

*OPTIONS:*

*I've never heard about one/some of the instruments mentioned in the quiz*

*It has been the first time I listened to this piece of music*

*I have never thought about how different sounds may be heard depending on distance*

*None*

## 8. Appendix III

### CANVAS

#### *For Technicians*

##### **Topics:**

- ❖ After this experience, do you think it is important that this could become a commonly used tool to ensure a better architectural / acoustic quality of a theatre project?
- ❖ Do you think that the auralisation tool is useful for your work?
- ❖ For acoustic designers: how do you think the auralisation tool can be useful for your work?
- ❖ For architectural designers: how do you think the auralisation tool can be an added value compared to traditionally used tools (e.g., rendering)?
- ❖ Do you think this tool could be useful for the choice of materials from an architectural and acoustic point of view?
- ❖ Can you think of another application in your field for which an auralisation like the one you just experienced would be useful?
- ❖ Additional suggestions

### CANVAS

#### *For Experts*

##### **Topics:**

- ❖ Have you ever worked with immersive technologies (apps with augmented or virtual reality)? And if so, in what context?
- ❖ Do you think that the possibility to activate / deactivate the different instruments on stage is useful for your work? Yes/No, for which reasons?
- ❖ Do you think that listening from different points in the theatre is useful for your work? Yes/No, for which reasons?
- ❖ Do you think that this tool could be more effective for a specific kind of theatre (e.g., opera house, drama theatre, concert house, etc.) and a specific kind of performance (e.g., classical concert, jazz/modern concert, opera, prose, musical)?
- ❖ Do you think that knowing the architecture and the acoustics inside the theatre before your exhibition could be important for facilitating your performance?
- ❖ Do you think this tool can attract new audience to the theatre? Yes/No, for which reasons?
- ❖ Additional suggestions from the experts

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