Organum pineale. Design and implementation of a site-responsive sound installation

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ABSTRACT

The paper describes the sound installation *Organum pineale*, that has been commissioned by the National Museum of Cinema of Torino in the occasion of the "#FacceEmozioni" exhibition, dedicated to the relation between face expressiveness and emotions. The installation is site-responsive and exploits the peculiar acoustic features of a part of the Museum building, the so-called "Orecchia". On one hand, the installation was meant to provide a sonic *analogon* of the main theme of the exhibition, in particular in relation to Descartes' conceptualization of passions. On the other, its design aimed at emphasizing the unusual acoustic features of the Orecchia, a visually empty space, but very rich on the aural side. *Organum pineale* features a 28 + 4.1. audio system, delivering sound materials originating from a selection of films, that have been tagged in relation to Descartes' six main passions. The overall sound process involves spatialized audio and a generative feedback system exploiting the room acoustics.

1. INTRODUCTION

In the occasion of the "#FacceEmozioni" exhibition (Figure 1, see [1]), the National Museum of Cinema in Torino commissioned a sound installation to the Electronic Music School (SMET), Conservatorio di Musica "G.Verdi" of Torino, and CIRMA (Interdepartmental Research Center on Multimedia and Audiovideo), Università di Torino [2]. The Museum is located in the monumental building of Mole Antonelliana: a vast space, originally meant as a synagogue, that was the tallest brick building in Europe at the time of its construction (167.5 metres) [1]. The Museum is well-known for its spectacular multimedia setting.

The commission by the Museum was meant to exploit a specific, and unusual, room in the Mole, the so-called "Orecchia" (literally: ear). Placed at the side of the main building, the Orecchia serves as a connective space to move

Figure 1. #FacceEmozioni playbill.

inside the Mole and it crosses two stairways, that are open on the same side of the room, allowing to enter/exit the space (Figure 2). As a consequence, the Orecchia is a sort of autonomous body, characterized by almost cubic proportions. The cubic shape does not include the ceiling, as the room is surmounted by a dome vault. Walls are made of stone and concrete, with complex decorations in plaster (Figure 9). A specific feature of the Orecchia is that it offers a visual paradox: it is completely empty, but at the same time it gives the audience the possibility to observe from a wide angle the roof landscape of Torino: in fact, two of its sides are completely occupied by windows (Figure 3). So, properly in the Orecchia there is a lot to see, nothing of which is related to the contents provided by the Museum. From another perceptual perspective –i.e., the aural one– the geometry of the Orecchia results in a peculiar acoustic behavior, the main feature of which is a clearly delineated harmonic resonance. In other term, the room is a strongly "tuned" space, a sounding board with an almost instrument-like nature. The commission by the Museum was to create a sound installation inside the Orecchia in relation to the contents of the "#FacceEmozioni" exhibition. The latter was centered around physiognomy, that is, the relation between human facial expressions and passions, from 1500 to the contemporaneity. In relation to such a theme, the main issue at stake in the sound installation design was how to convey a sound *analogon* of passions in

[1] http://www.museocinema.it/en/museum-and-ma-prolo-foundation/mole-antonelliana

Figure 2. Entrance/exit stairways in the Orecchia.

Figure 3. Audience inside the Orecchia.

relation to their facial expressions as codified from Renaissance up to emoticons while taking into account the history of cinema.

2. BACKGROUND

The sound installation, titled *Organum pineale*, is conceived around the acoustics of the Orecchia and aims at setting up an audible scene of the representation of passions in relation to cinema. In these terms, there are five main conceptual keywords at the root of the project: space, instrument, passions, representation and listening.

2.1 Space

The Orecchia is a transitional space, as the audience is passing through it, properly without performing any action related to the Museum's contents. As noted by [3] these transitional spaces, exactly because of their supposed neutrality and the freedom they ensure to the audience (as visitors are not supposed to be bound to the contents) represent an opportunity for sound art –also on the political side– for "installing a space in another existing space, both physically and sensorially, and metaphysically and mentally (as a space for reflection and emotion) – an interior space in an exterior space" [3, p.108]. *Organum pineale* thus aims at opening an inner sonic theatre inside the external space of the Orecchia.

2.2 Instrument

As previously introduced, the Orecchia has a particular acoustic behavior as it is properly a highly resonant space, centered around three main frequencies and their various harmonic components (see Section 3). Rather than attenuating this harmonic feature, our purpose has been to emphasize it. The main concept was to treat the room as a gigantic resonator, i.e. to let the passions "resonate" inside it. An audio processing chain has been developed by means of various filter banks in order to emphasize such a "tuning of the space" (to cite Murray Schafer [4]). Another feature has involved sound distribution: the room has been equipped with a system of 28 speakers in order to let the listener clearly localize the sound sources in the space. In this sense, *Organum pineale* is "site-responsive". The latter term has been proposed by [5] in order to point out how in electro-acoustic practices, in order to deliver sound in a specific space, the sound artist has to continuously take into account the way the space responds to the sound itself, thus closing a feedback loop rather than assuming it as a fixed framework like in visual arts ("site-specific").

2.3 Passions

One of the fundamental texts of the modern history of passions is the essay by Descartes, *Les passions de l'Ame* ("The Passions of the Soul") [6, 7]. Here, Descartes introduces his classifications of six fundamental passions (wonder, love, hate, desire, joy, sadness). This basic organization stands at the core of the whole exhibition "#FaceEmozioni". As the Orecchia is the terminal place of the exhibition route, and therefore acts as its conclusion and recapitulation, even if in an acoustic form, the installation has its pivot exactly in the six main Cartesian passions. Descartes is also at the origin of the title of the work, *Organum pineale*. Notoriously, the pineal gland was conceived by Descartes as the place where *res cogitans* and *res extensa* were able to find a contact/exchange, that is, where soul and matter meet. Pineal gland thus plays a pivotal role in the establishing of passions. Descartes' body organ is the first reference for the title, but indeed a second reference comes from the meaning of "organ" as "musical instrument". It can be said that the Orecchia (both as the ear and –at the same time– as the architectural space) becomes the "organ" of the passions.

2.4 Representation

Passions, even if they have a biological substrate [7], are channeled into cultures, defining variable stereotypical typologies [8]. As shown by exhibition, they are obviously a crucial element of investigation for the performing actor, whose job mostly consists in bringing them on stage (see the many contributions in [1]). From Renaissance to 19th century, physiognomy has been an attempt to construct a code of passions, and, apart from its scientific results, has prompted a wide corpus of reflections on the actor's expressiveness, including both the face and the voice. In short, one can say that there is therefore an audible physiognomy of the passions that is conveyed by the voice [9,

10]. This is particularly interesting in relation to National Museum of Cinema, as the latter plays a pivotal role in witnessing, through the history of cinema, how the actor's craft has constantly changed over more than one century in relation to different cultural sensitivities.

2.5 Listening

The fruition space is called "ear" because of its shape, and, as mentioned, this shape also translates into a very particular acoustic response. In *Organum pineale* this architectural ear, so to say, is then thought as a theater of listening. As a consequence, technological interventions have been devised so to be as invisible as possible, so that the attention of the audience would not shift from listening to the sound to looking to the technical gear. Perceptually, the Museum has a notorious spectacular setting that, even if multimedia, is strongly focused on vision. Thus, while entering the Orecchia for *Organum pineale* as the final step of the exhibition, the visitor, until then mostly a viewer, is meant to be converted into a listener. In this perspective, our installation is meant as an example of (rare) purely acoustic art [3].

3. DEVELOPMENT

For the realization of *Organum Pineale* we have built an acoustic system powered by a ring of 28 little speakers, plus 4 other loudspeakers and a subwoofer, and two microphones. The design of the installation has been constantly monitored on the physical space, so that properly it can be said that it was not only implemented but also conceived in details as site-responsive (Figure 4). A first analytical step has required to analyze the resonance frequencies of the space. To do so, we proceeded empirically by generating a sweeping glissando signal in the range between 35 and 80 Hz, delivered it into the Orecchia through the subwoofer. Then, we recorded it and analyzed the signal resulting from the sinusoidal source plus the contribution of the room. We found three main resonant frequencies corresponding to 58 Hz, 65.5 Hz and 68.5 Hz, the latter having the highest intensity. Apart from fundamental low frequencies, other frequencies resulted as harmonic components of the same fundamental tones. The two loudspeaker groups perform different tasks. The little speakers are meant to convey film voice samples, that act as an acoustic foreground. The four loudspeakers are responsible instead for a sonic background that is generated in real time from a feedback system and includes samples from the film soundtracks (see next section), while the subwoofer is traditionally deputed to convey low frequencies. All sound processing is managed algorithmically by means of a Max/MSP patch installed on a computer with a dedicated 32-channel sound card (Antelope Orion 32), that accounts for the 28 + 4.1 setup (the subwoofer signal is derived from the 4 background channels). Seven amplifiers have been used for small passive speakers, each responsible for 4 channels. The 4.1 background system is active, and thus autonomously amplified. The whole technical setup is listed in Figure 5, while Figure 6 shows

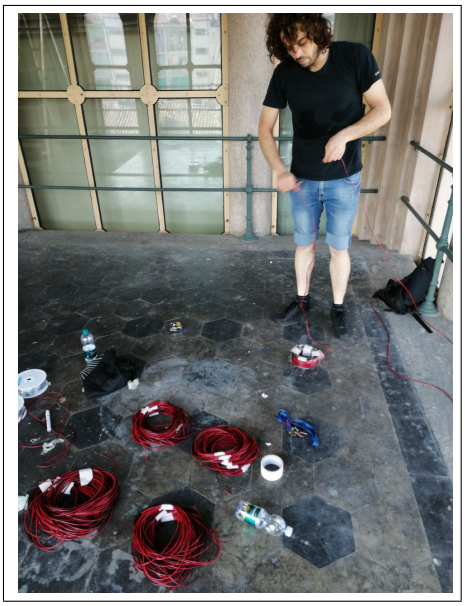

Figure 4. Cutting cables inside the Orecchia

Category	Product	Scheme short name	Quantity
Computer	Apple Mini-Mac	C	1
Audio Interface	Antelope Orion 32	AD-DA	1
Amplifiers	Auna C300 4 Channels 100W RMS	A	7
Mixer	Soundcraft EPM8	MX	1
Microphones	Movo LV8-D Omni-directional	M	2
Speakers	Array of 7 mini-speaker 3W	SA	4(7)
Loud Speakers	Alto TS 310	LS	4
Subwoofer	Alto TS 312s	SW	1

Figure 5. Technical setup.

the overall information flow. Details of Figure 6 are discussed throughout the next sections, the hardware setup is discussed later in relation to Figure 13.

3.1 Content organization

We selected a corpus of sound fragments (voice and soundtracks), extracted from films that we considered particularly significant with respect to the fundamental Cartesian passions. In cooperation with the scientific board of the Museum, 18 films have been taken into account, coming from various countries, genres, historical periods. For each, i) a soundtrack sample has been selected (see 3.2), and ii) various vocal samples have been extracted (for a total of 54) (see 3.3). The film sources are shown in Figure 7. As it can be seen, all samples have been tagged according to one of the six passions.

Samples are used as source materials to be processed and distributed in the space. Each passion is represented by a specific "tuning", both in spectral and spatialization terms, to be applied by the DSP algorithms. In particular, while vocal samples have been left unmodified in order to be clearly understandable, soundtracks samples have been processed by "tuning" them in relation to the Orecchia's

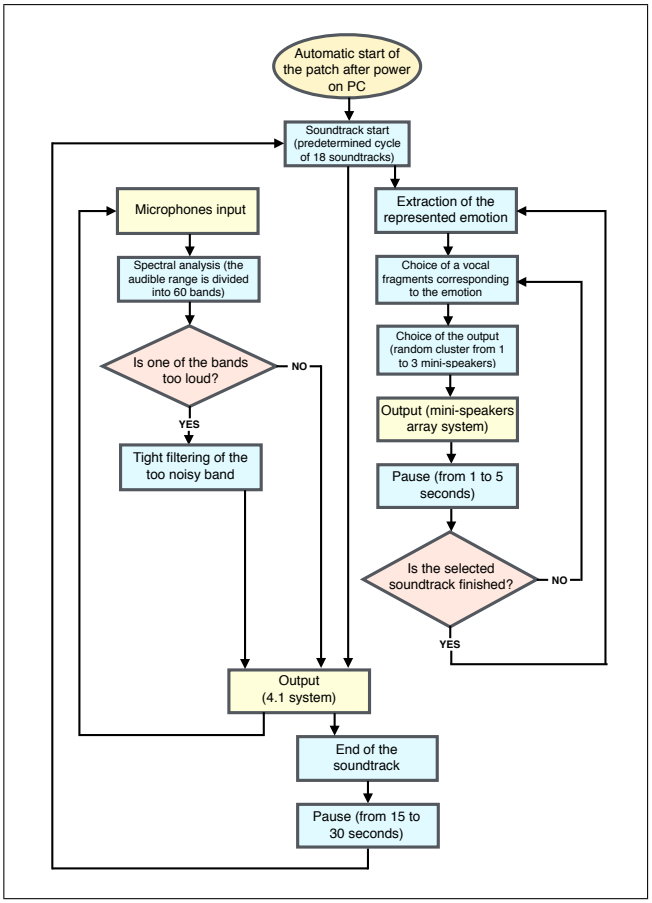

Figure 6. Logical flow of *Organum Pineale*'s control program.

Title	Director	Year	Emotion	Dialogues (54)
Breakfast at Tiffany's	Blake Edwards	1961	Love	2
When Harry Met Sally. . .	Rob Reiner	1989	Love	3
Gone with the Wind	Victor Fleming	1939	Love	6
The Bridges of Madison County	Clint Eastwood	1995	Desire	2
Call Me by Your Name	Luca Guadagnino	2017	Desire	3
Il racconto dei racconti	Matteo Garrone	2015	Desire	5
Forrest Gump	Robert Zemeckis	1994	Joy	2
It's a Wonderful Life	Frank Capra	1946	Joy	3
Risate di Gioia	Mario Monicelli	1960	Joy	3
The Wizard of Oz	Victor Fleming	1939	Wonder	2
Interstellar	Christopher Nolan	2014	Wonder	3
Totoro	Hayao Miyazaki	1988	Wonder	2
Kedmah	Amos Gitai	2002	Hate	3
Riget	Lars von Trier	1994	Hate	1
Seven	David Fincher	1995	Hate	2
Bonjour tristesse	Otto Preminger	1958	Sadness	4
Bram Stoker's Dracula	Francis Ford Coppola	1992	Sadness	5
Mission to Mars	Brian De Palma	2000	Sadness	3

Figure 7. Film selection and annotation.

Figure 8. PVC coulisse for the speakers.

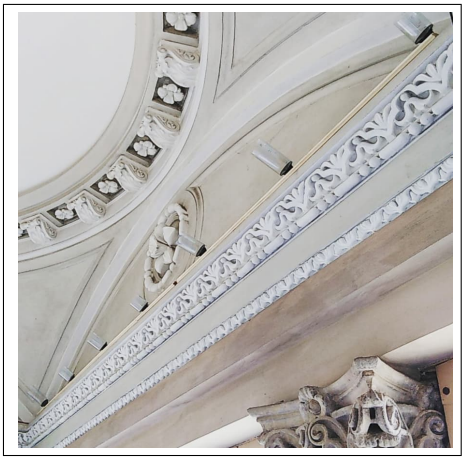

Figure 9. A detail of the Ring.

resonant frequencies, with the aim of exploiting what is typically considered a negative acoustic feature of a listening environment (i.e. strong resonances). In *Organum pineale* all the sound materials are played cyclically in a pre-established order: this "installation score" proved to be empirically effective, and is the only element belonging to a classic composition side in the whole process.

3.2 The Ring

The Ring is deputed to the spatialization of vocal samples, that are left unprocessed for sake of understandability. It is made up of 28 small speakers. The latter are 8 ohm passive speakers with a frequency range between 200 Hz and 15 kHz, and 3 W of power. They are amplified by 4-channel car amplifiers, a cheap but effective solution, given that no hi-fi quality can be provided by the speaker themselves.

As can be seen in Figure 8, each speaker is expanded with a PVC cone with a little *coulisse*: this allows the speaker to project the sound more directionally and to tune it according to the space resonance. PVC has been instru-

Figure 10. Speakers mounted on aluminum supports.

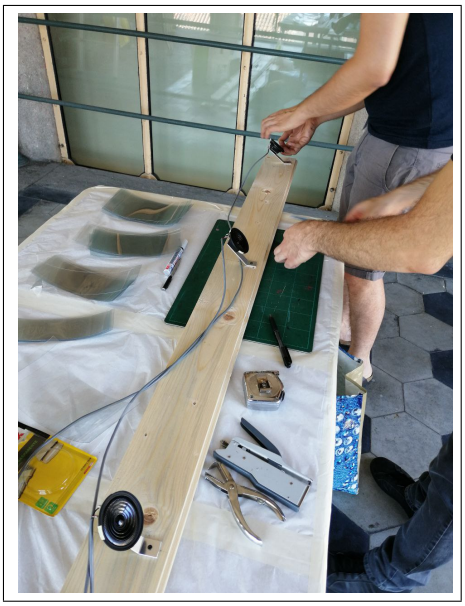

Figure 11. Fine tuning of speaker orientation.

mental in allowing an easy tuning as fine adjustments by trial and error could be done by cutting the sheets. This low-cost solution is inspired by electronic hacking tradition in electronic music [11] and has made possible to overcome budget issues related to dedicated, more expensive solution [12], such as Acouspade [2]. The 28 speakers are organized in a "Ring". The Ring has been placed on the ridge of the room, with 7 speakers for each side, organized into an array (Figure 9). These small speakers, partially hidden by plaster decorations, are the only visible equipment in the installation. Speakers have been placed on wooden boards, and hooked by means of aluminum bars (Figure 10). As aluminum is flexibile, it has been easy to fold the supports in order to set for each speaker the desired angle for audio projection (Figure 11). This fine tuning process was fundamental to obtain an effective spatialization. Overall control for the Ring is provided by the Max/MSP patch that determines in real time which vocal sample to use and where to place it in the space (Figure 6). While performing the passion sequence, the system selects a passion out of the six from Descartes. For the passion's defined duration (depending on available audio materials) the relative subset from the collection of vocal samples are loaded. An algorithm chooses randomly which speaker has to deliver the selected sample: the choice is constrained by an urn containing 28 values (representing each speaker), a matrix that indicates which speakers are free at the desired time (this available for sound delivery), and an index that allows the sound to be emitted by one or multiple speakers in a row. By means of this strategy, passing through the Orecchia allows the listener to ear voices coming from different angles of the vault. Every speaker is oriented toward a different point of the vault's surface. As the vault acts as an approximate parabola, the resulting effect for the listener is hearing voices speaking all around.

[2] ultrasonic-audio.com/

3.3 The feedback system

In *Organum pineale* a feedback system provides a sonic background for the whole installation. Feedback systems have a long tradition in electroacoustic music, be it analog or digital, as ways to generate complex, evolving sonic textures by exploiting the systems themselves [13]. From the hardware point of view, our system is made of four loudspeakers and a sub-woofer, plus two microphones, and it is completely invisible to the audience. The space of the Orecchia is substantially held upon columns, and the pavement has long, thin openings at its sides. Because of this, it was possible to hide the 4.1 channel diffusion under the pavement, in a service space, so that it can be heard without being seen. In order to emphasize the resonant features of the Orecchia, we designed a system that creates a controlled feedback from the room. The sources to be delivered in the Orecchia (over 4.1 channels) by this subsystem are samples from soundtracks. These same 4 audio signals are captured by two (hidden) omnidirectional microphones, together with vocal samples and the audio reactions by the audience in the Orecchia. The two signals resulting from the omnidirectional microphones feed an algorithm consisting of a bank of bandpass, adjacent filters with self-compensating amplitudes. As the output sound is fed back in the Orecchia by means of the 4.1 system, the result is a generative acoustic feedback system. Each filter instance is tuned around a region between two frequencies separated by an interval of semitone, with a slightly overlapping bandwidth: then, each frequency band is excited by a chorus algorithm that changes the amplitude envelope, each band's amplitude is then forced to oscillate between a minimum and a maximum amplitude value with a specific control frequency. As a result, the system dynamically increases and decreases each frequency amplitude over time. It must be observed that the microphones are placed in the Orecchia, so they also capture all the sound contributions from the audience passing by. In this sense,

Figure 12. The Ring.

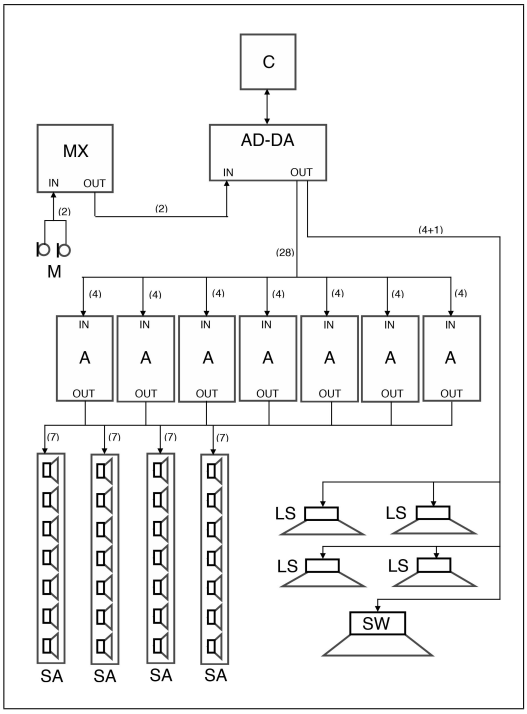

Figure 13. The hardware electroacoustic chain.

Organum pineale can also be thought as an audio-based interactive system.

The overall hardware setup is shown in Figure 13 (letters refers to Figure 5). To sum up, the two microphones (M) are connected to a mixer (MX), and their signals are sent to the Antelope sound card (AD-DA). Input signals are processed by a Mac Mini (C, computer) and multichannel audio is sent back together with the soundtracks and vocal samples to the soundcard. Then, 28 channels are amplified by 7 amplifiers (A) and delivered to the Ring (4x7 SA, speaker arrays). The feedback background is sent to the 4.1 system under the floor (LS, loudspeaker and SW, subwoofer). The microphones M capture the sound in the room, closing the feedback loop.

4. ROBUSTNESS

Organum pineale was open for six months [3] inside the Mole Antonelliana's Orecchia. Such a long opening has required us to create a very robust setup, as it would have been impossible to ensure an extensive technical support. For the same reason, the setup interface (startup and control) had to be very user-friendly, as it should be operated by the Museum staff. As a consequence, we designed *Organum Pineale*'s setup so that it could be switched on/off by simply pressing sequentially two switches in two electric plugs: then, with a two-minute delay an autolaunch program runs the application and no other procedure is required. Budget constraints have prompted us to create our own directional sound system, by means of small, cheap speakers surmounted by the PVC coulisses. The system has proven to be very effective, thus providing a low cost technical solution than can be fruitfully replicated. During the six months in which the installation was running, only few small problems have been reported: some coulisses fell down, and a small speaker had to be replaced. Robustness has proven to be a crucial feature in relation to two aspects: first, on the audience side, it was important that *Organum pineale* kept to seamlessly deliver sound output without interruptions; second, on the maintenance side, it was mandatory that interventions were to be reduced to the minimum, as any operation on the installation was to be supervised by the Museum staff for safety reasons, thus making it much more complicated to perform.

[3] From July 17th 2019 to January 6th 2020.

5. THE SITE, RESPONDING

The sonic result of *Organum pineale* is an immersive space, with people bathing in a continuum of sound streams. Informal reports we gathered from the audience (we hadn't the resources for collecting structured interviews) during the six months of its opening describes a sort of acoustic bubble punctuated by the incoming voices that acted as figurative, communicative pivots. A consistent part of the audience (youngsters mostly) discovered the feedback systems sending back their own processed voices and started experimenting with sound production to "test" the system. This feature underlines the "participatory" nature of the installation, even if it was not properly conceived as the result of a collective workshop [14]. Yet, another participatory feature lies in the shared design and implementation between teachers and students. As one of our team members wrote: "Working in this project has been a very deep experience in design and managing a complex artwork, thanks to our teachers who helped us understand the emerging issues, allowing us to pragmatically deal with them by exploring various possibilities; we have been able to learn how to work with institutions such as the National Museum of Cinema, handle technical material and experiment with it in relation to aesthetic choices". From reports coming from the Museum, the installation was very well received. In any case, an interesting issue has emerged. As we have discussed, the Museum is perceptually focused on vision. Moreover, the whole experience of the exhibition, culminating in the hall of the Mole, might be tiring for viewers. After traversing the hall, in order to exit the Museum, the audience had to go downstairs, thus passing through of the Orecchia. This final passage, so different from the previous aspects of the exhibition, has sometimes

Figure 14. Audience inside *Organum Pineale*.

proven to be difficult for the public, already tired or not willing to focus exclusively on hearing, as if they were under a sort of visual inertia because of the previous exhibition experience. Finally, the large windows offer a wide landscape, thus attracting the viewers' attention (Figure 14). This aspect seems to underline the more intrinsically difficult focus on aural perception than on visual one.

6. CONCLUSIONS AND FUTURE WORK

Organum pineale has proven successful both in terms of reception and in terms of shared working methodology. While strictly related by design to the space of the Orecchia, it has prompted more general design questions (purely aural art, site-specific construction, participatory feedback system) that we plan to address in the future. In fact, while it is not possible to strictly replicate *Organum pineale*, the format (i.e. exploitation of the space as an instrument to deliver some contents related to the space itself or to some specific theme) has proven very interesting, and the low cost technological solution very effective. In this sense, we plan to implement such a format in a possibly more contemplative, dedicated environment, be it cultural (e.g. church) or natural (e.g. cave).

7. CREDITS AND ACKNOWLEDGEMENTS

The concept for *Organum pineale* has been developed by Andrea Valle and Stefano Bassanese. Design and realization has been carried out by Guglielmo Diana, Matteo Marson and Luca Martone. *Organum pineale* is a production by SMET- Scuola di Musica Elettronica del Conservatorio di Torino in collaboration with CIRMA/StudiUm - Università degli Studi di Torino. Grazia Paganelli, Museo Nazionale del Cinema, has provided the film selection and annotation. We would like to thank Museo Nazionale del Cinema, and in particular curator Donata Pesenti Compagnoni for her constant support.

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