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Keywords (separated by '-')	Luigi Nono - live electronics - Venice - Pink Floyd - Renzo Piano

Technology as a Means of Musical and Artistic Expression: A Comparative Study of Nono's Prometheus and Pink Floyd's Concert in Venice in the 1980s

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Abstract. This study delves into the integration of technology into musical art, focusing on Luigi Nono's Prometheus and Pink Floyd's live performance in Venice. Despite their differences, both events represent pivotal moments in musical evolution, necessitating detailed analysis. This article explores the intersection of embodied cognition, music, and audience experience in Nono's opera Prometeo and Pink Floyd's concert, revealing the fascinating integration of technology into music. Nono's Prometheus, performed in 1984, and Pink Floyd's 1989 concert in Venice showcase distinct yet intertwined paths in the realm of live electronic music. This analysis considers the innovative approaches of both events, highlighting their impact on musical expression and the audience's perception. By exploring these iconic performances, this study sheds light on the intricate relationship between technology, music, and the human experience, illustrating the profound implications of their fusion for the future of musical creativity and audience engagement.

Keywords: Luigi Nono · live electronics · Venice · Pink Floyd · Renzo Piano

1 Introduction

This study compares some of the musicological and technical aspects of two live musical events, one of classical and the other of popular music, that took place in Venice, Italy, in the 1980's. These two very different cultural events revealed some interesting similarities concerning the way in which they were devised and implemented. Furthermore, Nono's *Prometeo* serves as a prime example of embodied cognition, merging mind and body through innovative sound spatialisation, and similar embodied experience is found in Pink Floyd's live concert. The aim of the present research was to focus on the use that was made of technology for the two concerts, and the innovative thinking behind said use.

Conducting this type of research has brought to light an important feature of every musical and cultural phenomenon, i.e. the existence of a link between the strategies for

using technology and the most often studied aspects of this phenomenon, aspects relating to the set of technologies acquired over the course of time and to the traditional approach to the concert, all episodes that play a part in the history of music. These situations can also give rise to a phenomenon of custom that profoundly influences the history and traditions of a culture, and of musical culture in our case.

The aim of this study, thus, was to focus on the technological aspects of this phenomenon, which is often disregarded due to ignorance or superficiality. I have also sought to combine marginal and ephemeral notions into a single document that could be consulted and revised by other scholars. From the material obtained for the analysis, there also emerged an aspect of the modernity of such research, and a consequent awareness of the experimental nature of this work. I consequently make no claim to have exhausted the field of investigation or even the material available for analysis, but merely to have sketched out a preliminary model for future, more thorough studies. The study method chosen for this purpose was based on seeking and filing as much information as possible, drawn from academic research, specialist and non-specialist journals, interviews, and website. Moreover, in order to keep the technical perspective as objective and up-to-date as possible, an effort was made to track down the largest possible number of opinions and different kinds of sources, wherever the situations permitted. As a consequence, although a huge quantity of material was collected, some information had to be rejected if the sources could not be considered entirely reliable and objective.

The events considered belong to two clearly distinct musical categories: the so-called classical music and popular music. Luigi Nono with his *Prometheus* ("*Prometeo, tragedia dell'ascolto*") and the Pink Floyd with a concert that was part of their *Another Lapse tour* produced two extremely different musical events, given the type of music and the type of audience involved, but what they had in common was a highly sophisticated use of technology and an impact on the city of Venice, where both these events took place.

Countless studies and discussions have focused on the distinction between classical music and popular music, but - given the character of this investigation, which aims mainly to further analyse the technological aspects of musical expression - my attention was concentrated mainly on the use made for these two sound events of the same electronic technology, albeit without neglecting an issue that emerged from an analysis of the material considered, i.e. the importance of the different musical concepts that lay behind their use of this technology. Luigi Nono's work breaks away from the convention that requires a frontal listening experience, with the audience placed in a separate area from the musicians. He represented his Prometheus inside a church, placing the audience at the center of this world of sound coming from a specifically-designed wooden construction occupied by the musicians. Though it may not seem so at first glance, this was done to facilitate an open, multidirectional listening experience. The Pink Floyd's performance, on the other hand, relied essentially on the conventional idea of a stage placed in the open air and paradoxically everything contributed to creating the usual frontal presentation of sound and lights. The artists took two opposite approaches: Luigi Nono wanted to combat the traditional, frontal representation, while the Pink Floyd aimed to exploit it to the full. Another aspect that emerged from our research is the contrast between Nono's principle of economy and a shared usage of the technological media, as opposed to the

principle of accumulation and individual usage of the technological media adopted by the Pink Floyd.

Nono was committed to using only a few technological functions but to exploit all their possible combinations; the Pink Floyd pursued a different objective, fully exploiting all the possibilities deriving from the juxtaposition of these technologies. As for the spatialisation of the sound, Luigi Nono and the Pink Floyd both made use of high-end technologies, obliging each of their listeners to choose their own individual sound space, by means of the Halaphon (Nono), or by reinforcing the mass frontal listening modality with principles drawn from quadraphonics (Pink Floyd).

Both the concerts were criticised at length in the newspapers and were a source of debate and sometimes of political discussions: Nono was criticised for having created a costly work that was difficult to understand, the Pink Floyd were accused of attracting a crowd of 200,000 spectators, who were guilty of damaging and polluting the city.

2 New Sonorities

Around the 1950s, there arose a compelling need to merge musical expression with the burgeoning scientific-technological realm. This synergy gave birth to live electronic music, a genre characterised by improvisation and constant evolution. Not confined to classical music, this genre found its footing both in classical and popular music domains, each enriching it with distinctive features. These live electronic performances, driven by impromptu technical choices, depended on the dynamic interaction of space, creating unique and ever-changing auditory experience.

Among musicians and composers of this period was born the idea of performing real musical workshops, where the combination of electronics and music could create splendid stylistic innovations. Only in the year 1955, the Studio di Fonologia della RAI established in Italy, more precisely in Milan. The Studio aimed to address and exploit electronic resources as well as the processing of recorded sounds. Many musicians operated together on his project; Luigi Nono - who embarks on his path towards live electronics- was one of them.

Live electronic music gradually paved the way to a growth in the number of live concerts, because this is a genre closely linked to the use of improvisation, or the so-called work in progress [1]; it is thus different from traditional instrumental music [2]. By live electronics I mean a set of technologies and electronic instruments that enable sounds to be processed and controlled starting from live acoustic sources. This tool (live electronics) has been used in two ways, i.e. both to expand the possibilities of instrumental music and to serve as an electronic instrument per se. Live electronics are in themselves a form of work in progress, or real-time elaboration and creation, which is why it they demand the presence of a musician and a composer; and both these figures interact with what they hear.

2.1 Live Electronics: Bridging Classical and Popular Music Through Sonic Innovation and Spatial Exploration

Live electronics is not an instrument that belongs to classical music; it is usually found in the live concerts of popular music groups. In classical music, we can see that there

is a composer in the role of conductor of the orchestra and/or sound director, while in popular music the musician-composer is also the director of his own sounds at one and the same time.

Despite the existence of a precise program for its execution, a live performance using live electronics will be different every time because of the impromptu technical choices that are made in each case. One of the indispensable elements enabling this variability is the use of space. The attitude of a composer required to choose the space in which to represent a work may go in two directions: he or she may opt for a given place because it has certain special characteristics, or decide to change some of the parameters of the concert and the instruments involved to adapt them to a place. Either way, it is of fundamental importance to consider the space in order to fully exploit the sound effects.

Already by the end of 1970, live electronics was no longer considered a novelty and in the musical world it was consequently occupying a space in both classical and popular music, but with different characteristics.

In the context of classical music, Luigi Nono performed his Prometheus already in 1984, while in the world of popular music, the Pink Floyd brought a live show to Italy in 1989. Both held their concerts live in Venice during the 1980s, using live electronics for different purposes. These artists also have another aspect in common that emphasises their affinity, and that is the need to experiment, to seek new sonorities and a new music that does not necessarily have to appeal to the audience, but that can make new inroads into the world of music.

Their performances both immediately aroused a great deal of debate in the artistic world of the time, and some criticism from various quarters. In the end, however, these artists came to occupy a place in history for the grandiosity of their projects.

3   The Research Behind Prometheus

Nono's Prometheus transcended conventional boundaries, embodying an innovative and ongoing critical analysis of musical language. This masterpiece, unshackled from traditional theatrical constraints, presented a revolutionary fusion of sound and color, captivating audiences with its visceral impact. At the heart of Prometheus was a visionary partnership between Nono and the Institut de Recherche et Coordination Acoustique/Musique (IRCAM), enabling the exploration of live electronic music. Through intricate band-pass filters and inventive spatialisation techniques like the Halaphon, Prometheus pushed the boundaries of live electronic manipulation, immersing listeners in a sonic universe. Nono gave his first representation of Prometheus in 1984 at the church of San Lorenzo in Venice. The character of Prometheus represents a constant search that leads to the character finding, fixing and transgressing the limits; he is the incarnation of restlessness and curiosity about what is unknown and "something else" [1]. Nono combined this with his own personal need to conduct an ongoing, innovative critical analysis of the language, in order to be able to "Cross the threshold and wander beyond the doors opened up by modern technology, to draw on new perceptions"[1] p.367 [3]. But it also represents the "tragedy of listening" because it means "constantly seeking all these secrets of sound

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[1] "Varcare e vagabondare oltre le porte aperte anche dalla tecnologia d'oggi, per attingere nuove percezioni." [3].

and space" p. 335 [4], a search that Nono conducted meticulously, studying all the spaces of the churches in Venice - a city for multidirectional listening - arriving at the church of San Lorenzo that was to host the premier of a historical event. Nono saw Venice as an acoustic environment suitable for transmitting sounds, a city whose waters and canals carried the sound waves.

For Luigi Nono, space was the essential element of the compositional process: in composing a work, every artist should imagine it set in a given space in order to bring it to life; the space thus becomes an instrument in itself, a voice, "[..] an integral part of the musical event" p. 494 [5]. It is because of this innovative use that he makes of space that it is impossible to establish a score suitable for performing anywhere, and his work is continuously transformed in relation to the architectural space where it is to be performed. At San Lorenzo, Luigi Nono sought to identify the various opportunities that the spaces in the church gave him to change and manipulate his score in a process typical of live electronics, a topic that he had studied in depth in Freiburg.

The musical production was arranged into four orchestral groups: soloists, choir, instrumentalists and live electronics, which managed 24 loudspeakers [5]. These components were placed in Renzo Piano's Ark, a wooden structure organised vertically and horizontally, where the movement of the sound spreads both internally and externally. As Prof. Vidolin explained "[..] live electronics […] takes these natural sounds [..] and manipulates them, treating them and transmitting them in a continuous movement, or on different planes of sound, outside the space for listening to them [..]. Sometimes there were even synthetic sounds under the floor of the auditorium, sometimes in the middle of the hall" p. 379 [6].

In Prometheus, the use of light and color also takes on a function related to the sound [7]. As the composer himself stated "the stage box cancels the static nature of the visual element […] precisely for a different use of the auditory element, […] with new acoustic diffusion techniques" p. 210–15 [8].

Nono uses color as a tool closely connected to the music, but without allowing it to override the sound or misrepresent to the ear what it is hearing. Quite the reverse, the color has to further investigate the force of the listening experience, so it must not distract the audience. That is why in Prometheus he uses a cold, inconsistent light, that is non- descriptive. The movements of the light must rely on very slow changes of shade, taking as long as a quarter of an hour to go from black to grey and proceeding independently, not following the music. The person chosen as lighting director was Emilio Vedova, who - being a painter - was a great expert on colours. The initial plan for Luigi Nono's "Prometheus" included a color projection inspired by the theories of Goethe, Runge, Itten, and Kandinsky. However, this idea was abandoned during rehearsals, leaving Emilio Vedova with the sole responsibility of managing the lighting. At this point, Nono was resolute in his vision: "Prometheus" was not to be an opera, but a sound-based tragedy interacting with two distinct spaces, devoid of any staged or visual elements [9].

Nono's color scheme, which is well-documented in sketches and interviews, involved thirteen colours, each with twelve different shades. Unfortunately, Nono's annotated edition of Goethe's "Farbenlehre" has been lost.

The concept was to navigate through various color shades and use them, along with the music, to 'explore the space'. This idea is mentioned in a letter from Nono to Piano dated December 6, 1983 [9].

4 Luigi Nono's Innovation

Prometheus, devoid of traditional theatrical embellishments. Rooted in ancient mythological themes, Prometheus redefined the essence of listening, challenging established norms with its avant-garde brilliance. Nono's intricate use of live electronic music involved detailed phases of electronic treatment facilitated by band-pass filters and cutting-edge spatialisation techniques. However, beneath its technical complexity, Prometheus remained one of his most important work, transcending the confines of traditional music and ushering audiences into an immersive auditory universe. Nono produced Prometheus with an unconventional theatricality that already existed in his previous works ('Intolleranza', 'Al gran sole carico d'amore') and he came to reject the visual dimension apart from the use of color as an introspective guide for the audience.There is no libretto for his work: the text is actually a synthesis of different texts in Italian, German and Ancient Greek on the legend of Prometheus. The text draws from "Aeschylus, Pindar, and Hesiod". Prometheus is the bearer of fire, seen by some as the last of the old gods battling against the young gods, symbolising the contrast between the conservative and the innovative way of thinking. Nono's work therefore aims to stimulate innovation, an innovation that includes the use of the new electronic technologies in a construction designed exclusively for the audience's introspective listening experience. Prometheus is not acted theatrically, with actions taking place on stage before an audience, nor is it based on any particular story; these are the characteristics that make Prometheus the most important of Nono's works. The eyes make way for the human ear to take in a polyphonic work that deals with the mythical past, present and future; a work capable of creating a new sound spatiality around the audience with fragmentary sounds that are sometimes disconnected from the original text.

In an interview Luigi Nono explained how the projects relating to the visual plane of Prometheus were born: Cacciari saw the opera as an archipelago of numerous islands; and Renzo Piano designed these islands suspended in space [10]. To show how to navigate between them, there would therefore be a path of coloured light projected onto the walls and onto the audience. Initially, the interest in the sound/color combination visually represented within the opera attracted attention and produced great results. Despite the originality of the first Prometheus project, Nono soon abandoned these ideas, however, driven by the need to make more space for listening - a need that Luigi Nono called an anti-visualistic syndrome pp. 70–71 [10].

4.1 A Massive Sound Box

In the context of Prometheus, the collaboration with Italian philosopher and writer Massimo Cacciari holds significance. Massimo Cacciari, renowned for his philosophical insights and interpretations of culture, provided a fundamental intellectual contribution to Luigi Nono's work. His philosophical vision permeated the conceptualisation

of Prometheus, enriching it with profound meanings and philosophical implications. Through his collaboration with Nono, Cacciari contributed to shaping the theoretical and conceptual framework of the opera, offering a unique interpretation of mythological themes and the exploration of sound and space. The partnership between Nono and Cacciari created an interdisciplinary dialogue that further enriched the work, transforming Prometheus into an artistic creation imbued with philosophical depth and human sensitivity. As Cacciari claims: "We needed a place for this particular listening experience. An instrument that would make it possible, that [..] would detach the listening from the "seeing" normally dominant in concert halls and opera houses. [..] A place where the listening is not distracted and can reflect on its own origins" p. 21 [11].

This is how the philosopher defined the importance of constructing an instrument designed to contain the whole event. The architect Renzo Piano was employed to build what many nicknamed the "Ark", but that he himself defined as "a massive sound box" p. 59 [13]. The construction stemmed from the need to simulate a sort of archipelago, where there were five (musical) islands. When you are on an island forming part of an archipelago and you gaze all around you, you will never be able to embrace the whole system because the human visual field is limited. Instead, you will be able to perceive and imagine sounds that are behind you [12, 13]. That is how the Ark was born, like an archipelago with the audience at its center, surrounded by musical islands that they can never see all at once, though they can perceive their presence thanks to the music.

Piano was inspired by the idea of an uncompleted wooden boat, in which he had built a "sound box" more than 3 m above the floor. The construction consisted of four scaffolding walls extending parallel and perpendicular to the walls of the church, on the sides of which there was a system with three levels of overlapping walkways, on which the musicians and soloists move about. Being placed on different heights, the three levels were connected by stairways. In various parts of the construction screens were also installed, by means of which the director Claudio Abbado and the deputy director Roberto Cecconi simultaneously directed the instrumentalists. Prometheus gave priority to the spatial nature of listening, which is why the 400 members of the audience were accommodated in the middle of the Ark, on chairs that could turn both clockwise and anticlockwise to some degree, and tilt forwards and backwards: the audience was thus given an instrument for seeking out the sound, in a search that is the characterising element of the opera, and that makes the audience at one with its protagonist, Prometheus.

4.2 Live Electronics in Prometheus

"[..] with live electronics I think the listener has to have a much more active role. The live electronics system broadcasts composite acoustic signals in the hall, but these vagabond sounds vary in quality, they are transformed and combined, and they must also be connected together by the listeners, instead of simply passing through them" p. 83 [14]. This consideration of Nono's explains why he used live electronics. In Prometheus, the listeners are not just given a composition, they themselves are cast in the composer's role to some degree, immersed in the space of the sounds. The opera involves the use of the 4i system: this is a computer-based for sound synthesising system that stemmed from co-operation between the CSC (Centro di Sonologia Computazionale) in Padova,

the LIMB (Laboratorio per l'Informatica Musicale della Biennale) in Venice and the IRCAM (Istituto di Ricerca e Coordinazione Acustico/Musicale) in Paris.

The system comprises a 4i numerical processor, a PDP-11/34 digital processor that handles the controls process, and a console of manual inputs suitable for live performances (Fig. 1).
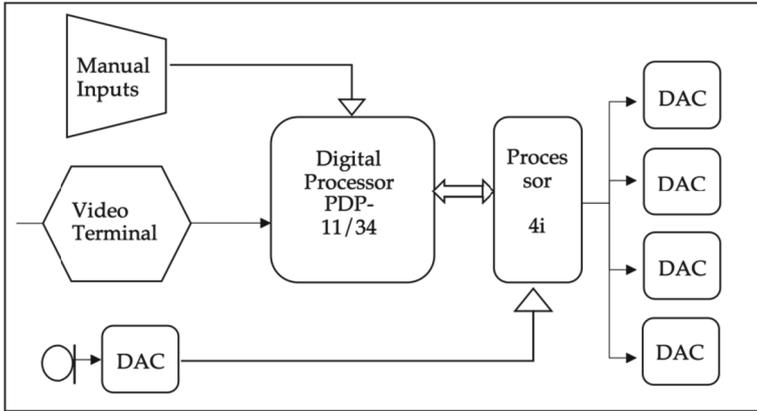

Fig. 1. 4i system and its parts.

The 4i numerical processor includes: 64 oscillators, 32 envelope generators, 96 oscillators, 32 timers, 150 adders, a 64K memory for the sampled waveforms, which can contain up to 16 different functions of any type, and 4 output channels each with 90 dB dynamics. All these units can be interconnected with one another in an infinite variety of ways to obtain different sound processing and synthesising outcomes. So we can apply additive technology (obtained by connecting several oscillators in parallel), amplitude modulation (by multiplying two or more waveforms), frequency modulation (by connecting 2 or more oscillators in series), non-linear distortion (by distorting a periodic wave, which is usually a sinusoid, with a polynomial frequency), subtractive technology (obtained by connecting several filters, i.e. linear combinations of delayed sums and multiplications, in series and/or in parallel), and reverberation (obtained by delaying lines, exploiting the memory of the functions).

In an interview with [15], Nono said that the 4i was used to produce synthetic sounds where live electronics was unable to do so, and these sounds were combined in real time with the sounds that live electronics then converted to obtain a mobile sound [15], in which the two signals mingled and combined with one another. Using the functions of the 4i also made it possible to reach levels of pianissimo as low as 0.50 dB, below the threshold perceived by the human ear, and the same applied to the high notes.

Live electronics involves electronically treating "natural" sounds and consists in listening to an original instrumental sound through loudspeakers; this sound can then be mixed with the electronically modified version of that instrumental sound, so it is not the musician who manipulates the sound. All the equipment used to treat sound electronically (microphones, loudspeakers, and live electronics per se) are considered as

instruments and they consequently occupy a visible place in the concert hall; the sound technicians and musicians also co-operate as peers.

The electronic treatment of sound consists of three phases:

(1) Sound conversion

Ring modulator - Harmonizer (audiocomputer) - Vocoder (voice coding system).

In the harmonizer (Fig. 2) the natural signal can be shifted one octave higher and two octaves lower; it also has a "reverse" function. Nono used such a transposition to create micro-intervals in two female soprano voices that would have been impossible to achieve live. The input signal was converted from an analogical into a digital signal so that the data could be processed numerically before it was converted back from digital to analogical to make the sound audible.
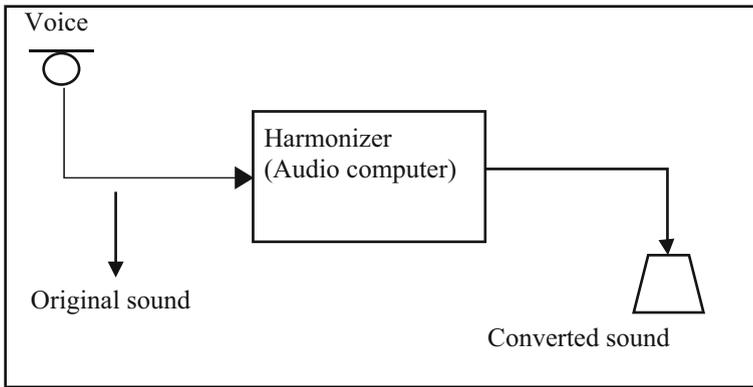

Fig. 2. Representation of the Harmonizer in Prometheus that varies the pitch of the sound without changing its duration and transposes the high soprano, the male choir and the bass flute.

(2) Sound selection

Only a certain field of sound frequencies is selected from a given sound by means of special third-, second- and fifth-order filter banks. It is worth noting that it is important at this point to select which sound to "enter" and improve. We can obtain a filter bank by aligning several pass-band filters and, depending on the filters' range of action, we can speak of second-, fifth- or third-order filters.

(3) Gate

The opening of the gate is governed by and directly proportional to the intensity of the microphone pulse, and the loudspeaker can be used to hear the live or converted sound of the instrument (Fig. 3).

The microphone becomes an instrument by means of which musicians can interact with one another and, at the same time, they can interact with their own sound.

A Halaphon creates a spatialisation and a continuous dynamicity of the sound in space by means of the loudspeakers (Fig. 4).
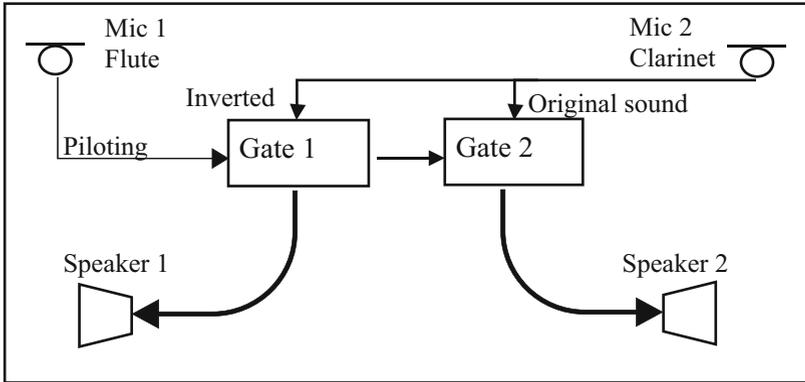
Fig. 3. Representation of the Halaphon employed in the Prometheus
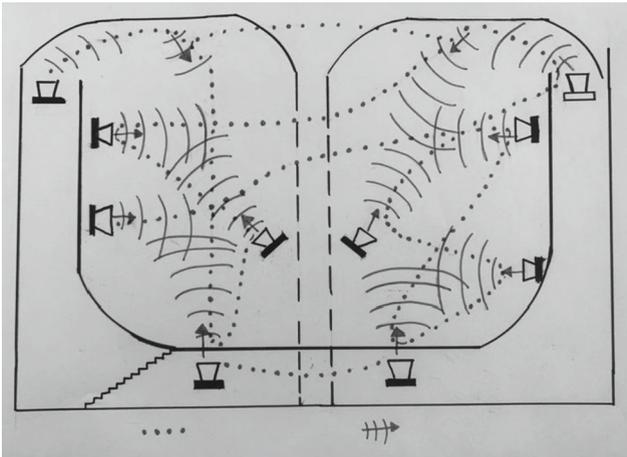

Fig. 4. Reproduction of Nono's draft-memo on the spatial movement of the sound of Prometheus, at the church of San Lorenzo[2].

The electronic instrument is therefore capable of interacting harmoniously with the acoustic instrument.

A great deal of importance is also attributed to the sound engineer (or sound technician), who - on a par with the director of the orchestra - must adjust and correctly articulate the sound sources within the space.

The section dedicated to *Hölderlin* is an example of the fascinating use of live electronics in Prometheus.

The instruments used are two sopranos, a double bass clarinet, a bass flute, and two reciting voices. In this piece, the voices of the two sopranos enter two different delay

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[2] http://www.jia-tokai.org/archive/sibu/architect/2003/0310/ongaku.htm

circuits (*delay* with accumulation[3]) of 4" and 8" respectively, and subsequently undergo two different spatialisation processes calculated through the Halaphon (Fig. 5).
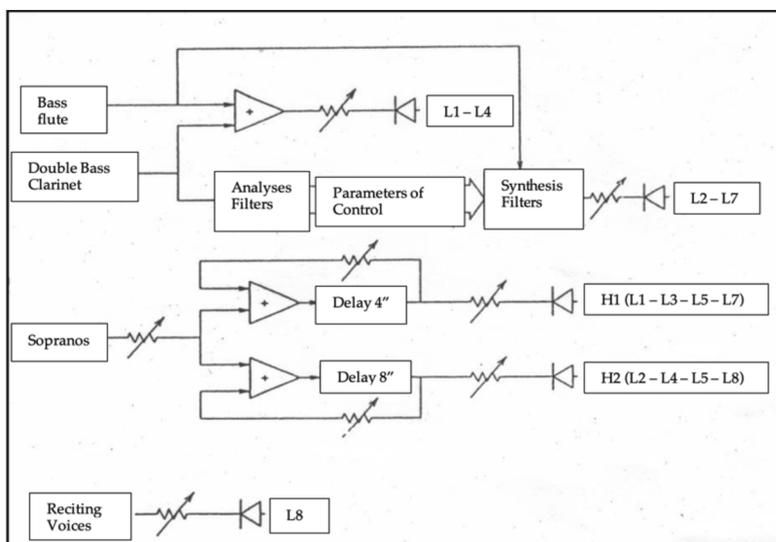

Fig. 5. Filtering bench for the analysis of signals transformed into pilot pulses of proportional size.

Halaphon and delay feedback are manually adjusted by two potentiometers: the first allows the user to adjust a sound through the speakers at two different speeds, while the feedback controls the "repetition density" of the signal; by regulating it, therefore, the increase/decrease of the overlapping of items is decided. The two spatialise voices follow two opposite paths thus producing an obsessive chorus that envelops the viewer. The sound of the double bass clarinet enters a first filter bench, where it is analysed. The filters of the second bench (the synthesis bench) are then subsequently opened through the pilot impulse coming from the analysis bench; the opening of them corresponds to the intensity of the pilot impulse that generates it.

This type of manipulation applied to the two instruments can be defined as cross treatment [6]. In it, the so-called pilot sound is analysed in real-time and one or more parameters are extracted from it to control the sound processed, coming from the analysis bench.

For the rest, the filter banks for analysis and synthesis are the same[4]; the linear connection that usually binds them is, however, reversed in this passage. The filters that operate in the low registers are associated with the high ones and vice versa. Consequently, the sound impulses coming from the contrabass clarinet will drive the sounds

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[3] Repetition of the sound for a certain number of times.

[4] Two banks made up of 48 bandpass filters, the bandpass filter is a system that lets all frequencies between two values pass: the lower cutoff frequency (at low frequencies) and the upper cutoff frequency (at high frequencies).

of the bass flute, opening the filters that highlight the high harmonics of the flute sound. Finally, the two reciting voices are amplified.

5   Light Show and Psychedelics: Visual Perception as a Mnemonic Support

In the realm of music performance, Pink Floyd dominated, captivating audiences with their mesmerising light shows and psychedelic visual elements. This amalgamation of auditory and visual stimuli crafted a mnemonic landscape, channeling music into the minds of spectators. The synchronisation of lights with music, although not universally synonymous with their concerts, became an integral component of their live performances. Their innovative fusion of lights and sounds underscores a deliberate effort to enhance the listening experience, expertly blending technology and artistic expression. Indeed, right from their very first show, the Pink Floyd demonstrated an interest in and attention to their visual impact on their audience, as we can see from the covers of their albums and their video clips, where the image becomes a mnemonic support for a spoken message.

For the Pink Floyd, every concert was an opportunity to use powerful new scenic effects to stun their audience. The group made use of a vast array of lights and motorised lasers, and a great variety of colors to achieve an effect of continuous movement. In fact, very often the lights moved in step with the rhythm of the music of their songs, so that the light show provided a mnemonic support for the music: the audience would automatically link the musical message to the lighting effects. The Pink Floyd will go down in history for the grandiosity of their light shows (a term that became synonymous with their concerts), by means of which they also established certain habits with their fans, such as the surprise element that typically came at the end of each concert. The concert in Venice ended with an explosion of fireworks connected a little earlier to the traditional fireworks to celebrate the Festa del Redentore.

From the perspective of their usage of light, Luigi Nono and the Pink Floyd would seem to have nothing in common. In actual fact, despite their different approaches, both the composer and the pop group were attempting to reinforce this sound scenario, adopting two different styles: the former aimed to strengthen the sound effect through spatialisation; the latter combined the stunning effect of light in their musical representation. Both relied heavily on live electronics to achieve these goals.

5.1   Technical Organisation, Quadrophony and Live Electronics

Pink Floyd choose for the public a traditional-frontal experience of music as regards the division of musicians and the audience: the sounds come from a stage placed in front of the spectator. Despite this choice, the group intends to help listen to the public through satellite amplification stations.

The sound engineer Jerry Wing of Britannia Row describes[5] the system they provided for the concert as follow: a Maryland Sound Incorporated or a sub box made up of 4x15-inch cones with frequency response from 30 to 80 Hz and in a high frequency box

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[5] Jerry Wing, personal e-mail communication with author.

composed of 4x12-inch cones and a flared horn in turn powered by a TAD 4001 (a compressor), which extends the frequency up to 18kHz. Wing also writes that these speakers were powered by a rack of SAEP500 and CREST 7001 amplifiers all around 1000 watts per channel; each rack also has 4 amplifiers. The speakers were suspended thanks to straps: the first group of speakers (for the high frequencies) was hung with a strap, the next one attached to the first with other straps and so on for the other 40 heads (speakers for the high frequencies) and 40 bass subs for general PA. The engineer adds that for the quadraphonics stations the speakers used were Turbosound TMS3. Each combination of speakers, for treble and sub, was powered by around 3000-W amplifiers which gave around 120,000 watts to the main system per gig.

The latest information on the concert concerns the sound engineer Buford Jones who uses 2 Yamaha PM 4000s and a specially created Quad mixer to control the surround system. They probably aimed to apply the principle of quadraphonics to their live shows, and this is another aspect that relates them to the not very successful attempt to use the Ark that Nono commissioned from Renzo Piano, which involved more than mere quadraphonics, it aimed for a poly-centricity. Although the supply of these quadraphonics installations was confirmed by Britannia Row of London, it is hard to say how, and how much they were actually used at the Pink Floyd concert. From the images recorded live in Venice, it is unfortunately impossible to distinguish more than one quadraphonic
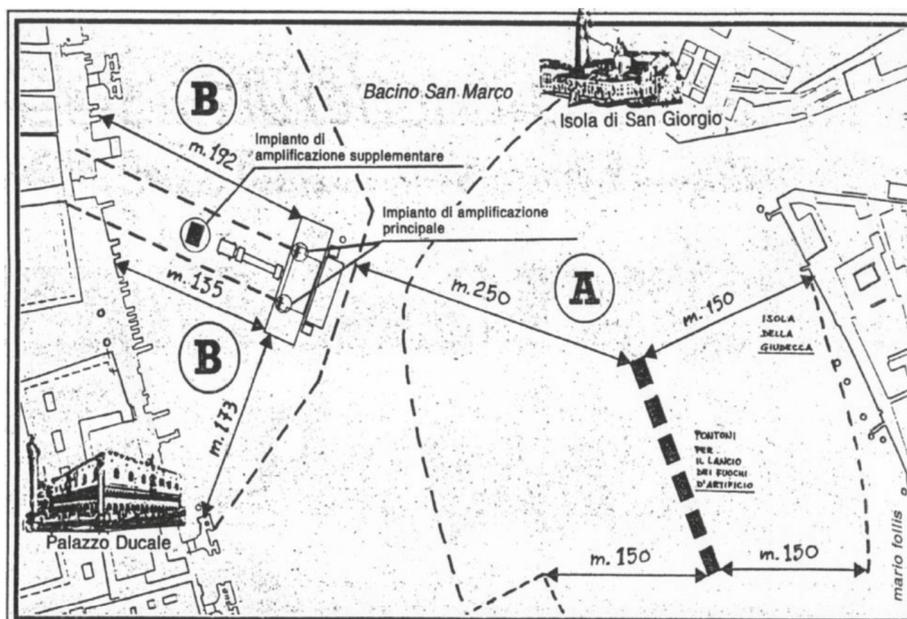

Fig. 6. Technical map of the concert of Venice, published in the daily newspaper "Il Mattino di Padova" [15].

station, though it is certain that a "supplementary amplification system"[6] was used (Fig. 6), located about 100 yards away from the front of the stage used for the concert in Venice. Based on information given by the sound engineer Wing (Britannia Row), we can assume that the Pink Floyd's quadraphonic system was conceived for the purpose of surrounding and immersing the audience in the music and in the group's visual spectacle.

6   Embodied Experience in Prometeo and Pink Floyd Concerts

Luigi Nono's Prometheus stands as an embodiment of musical cognition, a pivotal concept in cognitive psychology. Nono's work deeply intertwines with embodied cognition, where the mind is not separate from the body but relies on continuous interaction between the body, the environment, and experience. Nono didn't merely compose music; he sculpted a sensory experience engaging hearing, sight, and even physical movement.

For the audience, Prometheus offers total immersion in a sonic world that transcends mere listening. The innovative use of sound spatialisation creates a three-dimensional sonic environment enveloping listeners. Sounds appear to emerge from various directions, channeling the listener into a unique auditory journey. This sensory involvement transforms listening to Prometheus into a corporeal experience where the audience is not merely a passive spectator but an active participant. The innovative use of sound spatialisation, coupled with reclining seats facilitating movement, intensifies concentration, transforming simple listening into a complete immersion. Through this, the audience lives what Prometheus lives, forging a unique connection between the opera, the audience, and the surrounding space.

Yet, the experience doesn't end with the audience. Musicians, immersed in the intricate system of the Ark, become integral parts of this incarnate experience. Their interactions with instruments, the surrounding space, and the audience are fundamental to the performance. Musicians' gestures, their physical presence within the Ark's environment, and responses to sonic nuances intertwine their experience with that of the listeners, creating a unique synergy between performers and audience.

In the context of Pink Floyd, embodied experience takes on a different yet equally engaging form. Their remarkable blend of psychedelic lights, enveloping sounds, and energetic performances transformed their concerts into multi-sensory experiences. Audience members didn't just hear the music; they felt it deep within, as vibrations from powerful speakers reverberated through their bodies. Moreover, the undeniable star of the show was the sea, enabling the audience to experience music while on a boat, amplifying the sensory impact.

In both contexts, embodied experience becomes a bridge between art and human perception. Music becomes more than a sound wave hitting the ear; it evolves into an entity that embraces the entire body, involving the entire human experience in a symphonic dance of sounds, lights, and movements. This connection between Nono's work, embodied cognition, and sensory immersion in Pink Floyd concerts reveals the power of art in shaping not only our listening but also our perception of the world around us.

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[6] Alberto Vitucci, "I Pink Floyd suonano", Il Mattino (Padova), July 14, 1989, accessed December 12, 2020.

7 On Embodied Cognition and Live Electronics

Certainly, live electronics represents a fundamental evolutionary step in contemporary music. When we view these works through the lens of embodied cognition, we enter a territory where music is a total experience, engaging every aspect of our being.

Looking at the technological aspect, live electronics offers artists the ability to manipulate and shape sound in real-time. This isn't merely an exercise in musical creation but an active interaction between the artist and the instrument, often transforming the stage into a live sonic laboratory. The artist's physical presence, hand movements, use of electronic controls – all of these are part of artistic expression. These physical gestures become an integral part of the performance, an extension of musical intention that goes beyond traditional instrumental execution.

Simultaneously, the audience is drawn into a unique sensory journey. This perspective transforms music into an equally inclusive experience, accessible to all, eliminating distinctions between the audience and the artist. The sounds can surround listeners from every angle, creating a three-dimensional immersion. Music is no longer confined to the stage; it spreads throughout the entire space, interacting with the architecture of the environment and involving the audience in a synergy of sounds, movements, and tactile sensations.

This perspective of embodied cognition should not be merely an academic analysis but a guide for the listener. The significance of examining various music and technology-related events through the lens of embodied cognition has already been underscored by [16, 17]. It invites listening to music with the entire body, not just with the ears. Thus, works related to live electronics are not merely compositions to contemplate but multisensory experiences that engage the body, mind, and soul, forging deep connections between the artist, the audience, and the surrounding environment. In this context, music isn't just heard; it's felt, seen, touched, and lived at profound levels, revealing the power of art in integrating technology into our human experience.

8 Conclusions

In this article, I have examined two events that took place in Venice. The results of this research brought to light substantial differences between the two concerts considered. Although both events used live electronics, the first difference concerns the approach to their use. Nono employed a technology that was quantitatively limited to just a few elements, but exploited them in every possible combination. Conversely, a glance at the table relating to the Pink Floyd shows that their technological instrumentation was much more abundant and detailed, giving the impression of a cumulative use of the available material.

Other substantial differences concern the use of space and the interaction between artist and audience. Nono adopted a closed, circumscribed space inside a church; he commissioned an architectural construction with specific functions for the purpose of listening to sounds, on which he entirely focused the audience's attention; his aim was to achieve an immersive spatial involvement and he tended to eliminate any presence of images. The Pink Floyd, on the other hand, almost exploited the whole city of Venice,

but for a paradoxically traditional fruition, where the frontal dimension was emphasised by the previously-described light show and by an unusual use of quadraphonics.

Nono's construction was intended for a limited audience (there were approximately 400 seats available), where they were expected to remain seated while they awaited the sound event. On the other hand, the chairs allow the audience to turn some degree, in order to follow the sounds that surrounded them. The audience was new to the type of event, and it had been given no opportunity to know what to expect beforehand.

The Pink Floyd took a very different approach to its audience: the show was in the open air and it could be attended by anybody free of charge. The audience was consequently free to move around and interact with the sound. Unlike the case of Nono's concert, the pop group's performance was based on its interest in promoting a song album that was already on the market, and that their audience had therefore already heard.

It is important to emphasise that the reactions of the audience attending Prometheus were very different from those of the audience at the Pink Floyd's live performance. In the former case, the audience's comments were discordant, and often critical; in the latter case, the crowd of fans was enthusiastic (as was self-evident from the numbers who attended).

Another fundamental difference lies in the dynamic features of the two performances. Nono explored the whole dynamic spectrum, touching on sonorities that were sometimes hardly audible, sometimes extremely loud, but that generally demanded total silence and great concentration. Within a closed space, Nono created a sound panorama of such wealth that it reflected that of the city of Venice pulsing outside the concert hall doors, with which it was implicitly in conversation. The Pink Floyd concert, on the other hand, tended to use only the higher dynamic levels, to the point of risking penalties for exceeding the volume threshold imposed by Italian law; it sought to emphasise an artificial sound to wipe out the sound panorama of the city.

Both performances focused on a different spatial involvement from the usual, exclusively frontal fruition, but only Prometheus completely succeeded in this intent: the concept behind it lies in taking the spatial effect of the sound into account during the compositional process, considering it as the main aspect.

In conclusion, the two events considered here seem to share the ambition of occupying a position on a level with the high-end technologies of the time (the 1980s), as if they were riding the wave of the same "wave of the times". A more detailed study of the use made of such technologies nonetheless enabled to identify different (and sometimes contrasting) conceptions of the role of the audience, the sound space, the musical work of art, and its relationship with the place where it is represented.

In conclusion, exploring the integration of technology into music, embodied in Nono's Prometheus and Pink Floyd's electrifying live show, reveals a fascinating mastery of innovation and creativity. Despite distinct yet intertwined paths, both events resonate with a common aspiration: immersing the audience in a sonic odyssey guided by live electronic music. Nono's Prometheus stands as a testament to meticulous composition, where every note resonates with profound meaning, while Pink Floyd's visual and auditory ingenuity redefine the concert experience. These distinct yet interwoven paths underscore the limitless potential of technology in shaping the future of musical

expression and embody the concept of embodied cognition, where the mind's interaction with the environment plays a pivotal role in artistic creation. In this innovation, the legacies of Prometheus and Pink Floyd remind us of the boundless possibilities when art and technology harmonise.

While in this paper I introduces the concept of embodied cognition, in the final section, a more detailed exploration of how these artists harnessed embodied cognition to enhance the audience's immersive experience would undoubtedly enrich the discussion. Further exploration of these perspectives would provide valuable insights into the profound ways in which music, technology, and cognition converge in live performances.

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