

Point d.Origine from Mende to Chambord The Paths of an Evolutive Design Process

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Abstract

Point d.Origine is a musico-architectural installation that converts, through mathematical objects called “spherical harmonics”, the architecture of remarkable buildings into musical sounds and sequences. To experience it, the visitor takes a small object called a “harmonic lantern”, whose role is to geolocalize his/her position in the space of the building, and wears a noise-cancelling headset. Since the transposition is computed for each point within the building, by his movements and displacements, he generates harmonic sound trajectories of which he is simultaneously the composer, the musician and the audience. Everything happens like if myriads of sound droplets where suspended in the air, waiting for the lantern to cross them in order to be played. Since the sounds are polyphonic, the music that is heard at a given point depends on the trajectory that was taken to reach this point. If the visitor stays still,

the music stops. Our team has put a lot of efforts at all levels (design, functionality, ergonomics...) to make the installation simple and easy to experiment. People of all ages, from kids to elderly, have been able to try and enjoy it. For those who are interested in knowing more about the scientific, theoretical and technological roots of the project, the installation is accompanied by an exhibition in which posters, video animation and small sculptures describe the underlying processes, principles and methods. A first version of *Point d.Origine* was presented in the French Gothic cathedral of Mende, in 2017. The second version was presented in 2019 in the Chateau de Chambord, a fairly known historical monument. The passage from Mende to Chambord gave us a lot of opportunities to explore and improve all parts of the project, and to develop a technological premiere in terms of localization. In this lecture, we present the major evolutions that occurred between the two installations, in particular the complete

redesign of the harmonic lanterns and the development of new localization system, itself a premiere, based on a collaborative network involving the lanterns themselves and a set of small beacons fixed on the walls. These developments were required because of the number and complexity of the spaces within Chambord, and because of the nature of the audience, which is completely different from the audience in Mende: as the second largest castle in France after Versailles, Chambord welcomes more than one million visitors a year, generating a completely new set of environmental

constraints. Comparing the two systems in Mende and Chambord provides a clear illustration of the evolutive nature of the design process itself, and will allow us to demonstrate the multiple paths of adaptation that it must follow to react to changing external conditions.

Key words: Music, architecture, design, media arts, digital arts, music technology, spectralism

I - A Dream of Stone



Fig. 1 – The Chambord Castle, seen from the garden. The dungeon is the central part with the two middle towers.

From September to November 2019, we presented the interactive musical installation *Point d.Origine* in the Château de Chambord, the largest of a group of about 3000 castles known as the “Châteaux de la Loire”, from the name of the largest French river along which they are distributed in the Touraine region. Among all these buildings, 11 are royal castles, and 21 are of particular importance. Though Chambord is among

the first group, it was not originally conceived as a royal residency, but rather as a hunting pavilion for king François 1er, who started its construction in 1519. It was completed one and a half century later by Louis XIV, at which time it became sporadically inhabited up to 1840, when it was classified as a historical monument in the very first *Liste des Bâtiments Historiques de France*.

Chambord was built in the middle of a swampy land, where it replaced a smaller mediaeval castle. I was not a small technological achievement. Some parts of the castle are said to be built on 12-meters wooden posts, in order to reach a stable ground. A lot of the 1200 workers

died because of swamp fevers. A small river had to be deviated in order to carry by boat the required amounts of stone to the worksite. Then, after all these efforts, it was impossible to inhabit the castle most of the year, because of the cold and humidity that prevailed from autumn to spring. François 1er himself spent only 72 nights in it, and used it only for short hunting stays, or to impress foreign kings and leaders – which worked: Charles Quint, emperor of the Western Holy Germanic Empire, was invited there for one night. Shortly after his visit, he said to his sister that he never saw anything more beautiful than this palace arising from the depths of the forest.

All this gives clues about the principles that guided the construction of the building. Located far from any urban environment, in a place that was literally in the middle of nowhere, it was free to deploy a morphology that was almost uniquely based on primordial, symbolical and formal architectural principles, without any real consideration for context or function, whatever this function may have been. The first part to be built was the dungeon; it consists in a cube with a large cylindrical tower inserted in each corner, and a cone-shaped roof over each tower. The only concession to the context is the diagonal orientation along the four cardinal points: the towers face North, East, South and West, so that the façades face the four quarters of the world. This solar connection, encountered in many major architectures, already points out to a plan mainly determined by cosmological considerations, which is corroborated by a wealth of elements within the whole building. The central staircase is a double helix around an empty cylindrical core with parallelogram-shaped openings, allowing people that climb or descent the stairs to see each other without ever meeting. Almost every element in the castle is literally orbiting around this staircase. In the original plan, instead of being

symmetrical mirrors of each other, the four towers describe a helix around it, and their inner plan follow the same pattern. On each tower, all skylights, turrets and chimneys radiate from the centre instead of facing the same direction. The whole plan seemed to be conceived as a Solar System, the centre of which being occupied by the extraordinary staircase that symbolizes both the central Sun and the power of the king around whom everything is organized, and which has also been described as a “tree of life”ⁱ.

II - A Leonardian Cosmology

It is now a well accepted hypothesis that Leonardo da Vinci has largely contributed to the original plan. Though no written document supports it, several drawings from his hand seem to represent rather precisely the central staircase, as well as the different steps of its design. The helicoidal movement appears frequently in his texts and writings of the time, and can almost be considered as its signature (Fig. 2). Moreover, the idea of elements orbiting around a central Sun is fully coherent with the fact that, for several reasons including his own deductions and works by other scholars, he was convinced of the heliocentric model for the Solar System. On a more theoretical point of view, he once wrote that all figures of the sky are present on the Earth, and that all figures of Earth are present in the sky, so the idea of Chambord as a deliberate representation of the order of heavens by Leonardo, as they were seen in the time of François 1er, is fully plausible [1] [2].

This point as such should not be surprising. Each and every architecture on Earth, from the most precarious to the wealthiest, incorporates elements that makes it a representation of the cosmology of its time and place. There are even examples in traditional or tribal architectures of houses or villages in

which each and every element is explicitly associated, analogically or symbolically, with some elements of the heavenly world [3]. But in the present case, every consideration of practicality, functionality or relation with the environment is subsumed by the strength of the symbolical forces that twist not only the whole building, but the stone itself: in the upper sections of the stairs, it becomes distorted and carried away by the irresistible helicoidal movement, which in itself does not only describe orbiting bodies, but the movement of the planets around another body travelling in space, like if Leonardo also had the intuition that the Sun was travelling through the cosmos.

In this respect, in one of his manuscripts appears a statement that, read to the light of today's science, is simply staggering [4]. It first states that the propagation of sound and light follows the same mechanisms than the waves on water,

implicitly stating that they do propagate in waves. The wave hypothesis for the sound had already been stated by several scholars and thinkers, and can be traced to the Roman and Greek Antiquity, but Leonardo managed to support it by a strong argument that associated the echo with the reflection of waves on a solid wall. But the idea of light propagating in waves was so revolutionary at the time that it almost makes him look like a time traveler. The first scientist to formalize and demonstrate this hypothesis was Thomas Young (1801), more than two centuries later. This insight becomes a little more understandable when he writes that the idea came to him as he realized that the reflection of the light in a mirror was also similar to the reflection of waves on water, but this explanation is nothing but a supplementary confirmation of the power of his observational and deductive abilities.

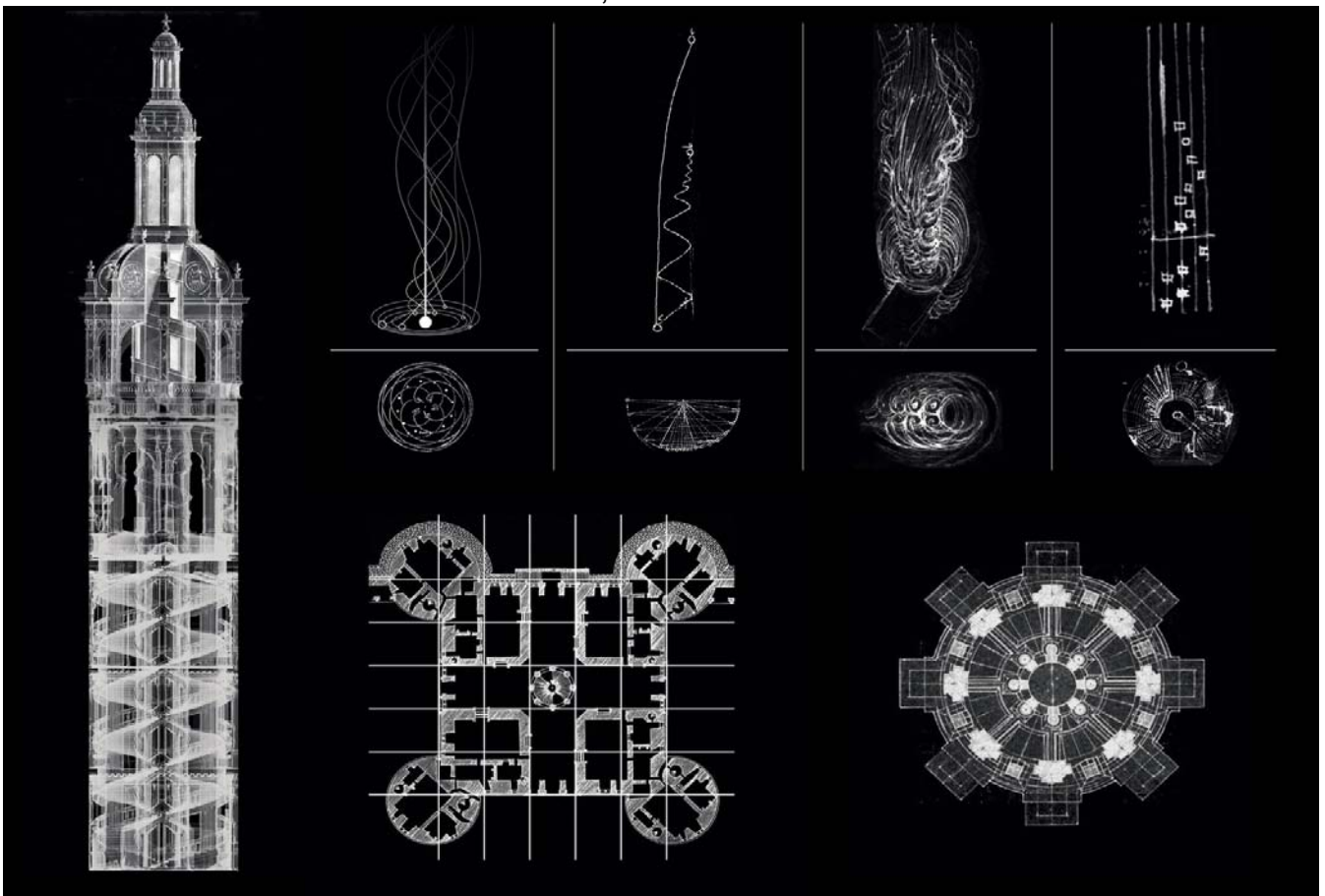


Fig. 2 – Helicoids in Chambord. Left - Cross-section and elevation of the double-helix monumental staircase. Top - four helicoid-related movements: planets trajectories around a travelling Sun; damping of a pendulum; vortex in water; musical rhythm. The three last drawings are from Leonardo. Bottom centre – Plan of the dungeon. The original helicoidal symmetry of the towers has been modified when the lateral aisles of the castle were added, which explains the mirror symmetry of the two top towers. Bottom right - Plan of the monumental staircase. The radial symmetry of the concentric elements evokes a radiating Sun around which orbit all the elements of the castle. The whole building is seen as an earthly representation of the Renaissance cosmology.

But this is not all. One of his most striking proposal resides in a paragraph where he proposes to undertake of an investigation program to look for the “amount of vibrations” in other elements of reality, such as weights, seasons, the areas occupied by the planets [5]. This amounts to nothing less than a program research aimed to provide an undulatory description for about all elements of the world. There again, this idea foresees another major discovery, namely the Fourier theorem (1801), by about two and a half centuries. Fourier was the first to mention the possibility to describe complex signals through sums of elementary waves; and the unification by Maxwell of all electric, magnetic and luminous phenomena under a same undulatory formalism came six decades later (1865). Further mathematical developments based on Fourier’s work now allow to describe any element of reality through a wave vocabulary, provided the preliminary definition of the proper kind of wave. In such descriptions, the waves used as elementary signals do not have to correspond to real, physical

waves: as we will see below, a wave description is a formalism that can be applied to any object or phenomenon, even non-undulatory onesⁱⁱ.

III – The Point d.Origine project

These considerations made Chambord an ideal place for the second study of our musical interactive installation *Point d.Origine* [7] [9], of which we already presented a first version in 2017 in the Cathedral Notre-Dame and Saint-Privat, in the city of Mende in Southern France [6] [8], another major historical monument with a very strong connection with the cosmology of its time. As mentioned in our previous work and lectures (see [3] in particular, but also [8] and [9]), *Point d.Origine* has been from the very beginning prepared and designed for architectural environments that can be considered as cosmological echoes. The very name of the installation comes from the history of cosmology, a history that could also be described as the history of the histories of the cosmos - of its current state and of its origins. To briefly sum up a theoretical and historical work that has been going on for several years, and that is described in the aforementioned works, most cosmologies and cosmogonies postulate the existence of a privileged point in the Universe, either in the form of a geographical centre, either as a temporal origin, or both. In the Western world, this central point was originally located on the Earth, or in its immediate vicinity. Cosmological developments up to the 20th century made it first oscillate close to our planet, then close to the Sun, to end up pulverizing it on every point of the Universe: in a relativistic cosmos, no point can be considered as a centre; or rather, every point could be defined as an immobile centre with the whole Universe revolving around itⁱⁱⁱ. The only privileged point that remains in such a world is my very position: it is the place from where I

contemplate and perceive the world, and from which I constantly evaluate my potential of action upon its elements.

This statement could seem very presumptuous if I did not add right away that the same applies for every human on Earth, or for every conscious being in the Universe; and that all these individual centres are constantly moving and changing according to our own displacements. From there came the name of the installation, which in French has a double meaning: from a Universe in which there is an origin point (*il y a un point d'origine*), we shifted progressively to a universe in which there is no origin (*il n'y a point d'origine*). Then, since every architecture is a small cosmology, a visitor in an architectural monument, especially - but not only - in a monument that is an explicit cosmological echo, must be constantly considered at its very centre, independently of the geometric centre of the building; and this centre travels with him when he wanders across the architecture.

In order to concretize the central position of the wanderer at each point in the building, *Point d'Origine* calls from another major aspect of antique Western cosmologies, namely its intimate connection with music. This connection naturally implies another connection between music and architecture, since the latter is *per se* a cosmological model. As a matter of fact, music and architecture were strongly connected to the Antique cosmos through the model of the Harmony of the Spheres. This model was actually acting as an immanent ordering force. It postulated that the distance between the planets were distributed along space intervals that were direct transposition of musical intervals; that this scale of proportions would determine not only musical scales, but also architectural scales; that it would control about every aspects of human life, from economy to

laws to phases of pregnancy to principles for living a good life; and that it determined the ideal proportions for the human body, which was itself a reflection of the perfect divine bodies of the gods and goddesses.

From the birth of modern science, the Harmony of the Spheres has stopped representing a valid cosmological model, but the connection between music and architecture remained strangely present since. During the following centuries, many artists and thinkers have noted a number of analogies and similarities between the two arts, despite the fact that the first is mainly an art of the immaterial, and the second an art of the material. Among them, Novalis, Goethe, Listz, Wright, Graves, Fathy, and many others, have stated in different forms that architecture is to space what music is to time, an approximate but illustrative sentence whose consequences cannot be overestimated. One of them is that music can be seen as an ordering and orientation mechanism in time, the same way architecture is for places; that a musical piece can also be considered as a small cosmology, through the distribution of its elements in time, and through the symbolical or analogical association of these elements with elements of the cosmos. Then, even after the complete invalidation of the Harmony of the Spheres in the 18th century, innumerable attempts have been made to associate music and architecture in different ways – poetical, analogical, formal... These attempts were diversely successful, but their very existence testifies of the conviction that a privileged connection between these two arts still exists. Moreover, musical analogies remain common in modern cosmology. Several major modern theories and hypothesis, such as Kepler's laws, De Broglie's model for electronic orbitals, and even the string theory (which today remains at the level of a hypothesis), have been postulated by

using principles that are deeply anchored in the musical field.

It is through these considerations that we developed the *Point d.Origine* installation, which provides the visitor – who from now we will also call “the wanderer” - with an experience that constantly positions him at the very centre of a cosmology represented both through architecture and music. For this, we had to establish a deterministic and reversible way to describe the architecture through a vocabulary of waves, and then to transpose these “architectural waves” into sound waves. The detailed description of the method we used is described in detail in our previous works [3] [8] [9].

The central principle of the method is, precisely, the possibility to use a wave formalism to describe any element of reality. We started a few years back to study the possibility to generate a full formal, deterministic and reversible transposition between a piece of architecture and a piece of music. The transposition principle might be better understood by realizing that when we describe an architectural object, we tend to use, like above, a description based on geometrical objects: cubes, cylinders, cones... and we tend to assimilate the architecture to these objects. As a matter of fact, a cube, or a cylinder, does not have any reality or physical existence. They are geometrical objects, and as such, they do not exist in the physical world. Any cubic material object can be described through a cube, but the object itself is not, and will never be, a cube – this would require an infinite precision that is not reachable with any material. Such geometrical descriptions are based on abstractions and on comparisons with abstract, virtual shapes. From there, it becomes easier to accept that any material object can be described through any set of abstract entities, provided a method exists for shaping these entities in

the likeliness of the object. After Fourier's theorem stated that any complex signal can be described through a set of elementary waves, it was quickly realized that any complex configuration of patterns or volumes could be considered as a signal – though at times a strange one – and thus be described through intersecting trains of waves that would recreate its shape through constructive and destructive interferences.

For several reasons, we decided to use spherical waves – waves running at the surface of a sphere – to decompose our buildings. These particular waves, called “spherical harmonics”, are particularly fit to our project because they imply for each transposition the existence of a centre; and that a centre could be associated to each of the potential positions of the wanderer, generating each time a new transposition.

IV – From the Cathedral of Mende to the Chambord Castle: an Evolutive Process

Mathematical, technological and computer science stakes were high for the *Point d.Origine* project. As mentioned above, we first succeeded in making it work at the Cathedral of Mende in 2017. It is after this first experiment, which, according to the visitors' comments and to the press reviews, proved fully successful, that we decided to try the transposition of a more complex building. Through contacts and encounters, we were able to propose it to the Château de Chambord – a building for which all challenges and constraints were greater by at least an order of magnitude – where it was accepted. The new version implied a series of major transformations in the system, which at the end amounts to nothing less than an adaptive evolution process. “Evolution” has a specific meaning; this word is used here to describe the transformations that

were directly induced by the new environmental constraints. It should not be confused with the design improvements that would have anyway been brought to the design after our first installation, without regards for the new context - very few such changes actually occurred made between the two events. It happened that one of them, the introduction of Bluetooth wireless headsets instead of wired ones, made the installation sensitive to environmental factors we did not have to consider before. As we will see below, we already know that it will generate a near future its own evolutive change for the third version of the installation. For now, we will concentrate on the environment-induced changes that were undergone between Mende and Chambord.

Before going through the description of this evolution, it might be useful to briefly describe how the first study of our project at Mende worked. From the very beginning, we decided to make the installation very simple to use, so that even children, elderlies, or people from all origins and with any level of expertise could experiment it. At the welcome desk, the wanderer was equipped with a headset connected to a small glowing module called a "Harmonic Lantern". A series of very small ultra-wide-band Wi-Fi beacons (UWB), affixed on the walls, constantly yields the position of the lantern with a 10-cm precision. To each potential position is associated a musical timbre that corresponds to the transposition of the building into sound waves, computed from this very position. Whenever the wanderer makes a movement, or walks in the spaces of the building, the lantern crosses these points, triggering the associated sounds, thus creating a harmonic trajectory of which he is simultaneously the composer, the interpreter and the audience. Everything happens like if the castle was a gigantic musical instrument, filled with small drops of music suspended in space, and that the

wanderer triggers by crossing them with the lantern.



Fig. 3 – The Harmonic Lanterns at Mende. These devices are individually held and connected to a headset. Their role was to geolocalize the visitors and to play the musical timbre corresponding to their position, with a 10-cm precision. Their design and morphology were almost only determined by functional and practical considerations.

The elements constituting the Chambord apparatus were essentially the same as in Mende. The design evolution they undertook was forced by major differences in the environmental constraints. These differences were caused by several factors, including the number and topology of the spaces to be covered, the potential number of simultaneous visitors, the thickness and composition of the walls, and several others. The following sections will describe the elements of answer that we brought for each of them, as well as the corresponding design modifications that were introduced for the new version.

1 – A Complex Topology

The first difference concerns the number and topology of the spaces to be covered. Though Gothic cathedrals are not simple architectures, the topology of their internal spaces is not that complex (Fig. 4). In most of them, the central nave is flanked on both sides by the collaterals; the collaterals connect through the deambulatory, which surrounds the choir; a transept crosses the nave. The space is

unified: there are no walls between the different elements, and the only obstacles to the view – and therefore to most electromagnetic waves – are the columns. Also, for reasons related to the amount of calculations needed, we decided to cover only the nave and the collaterals, which simplified again the space – it was basically made of a large rectangle with one narrow rectangle of the same length on each side.

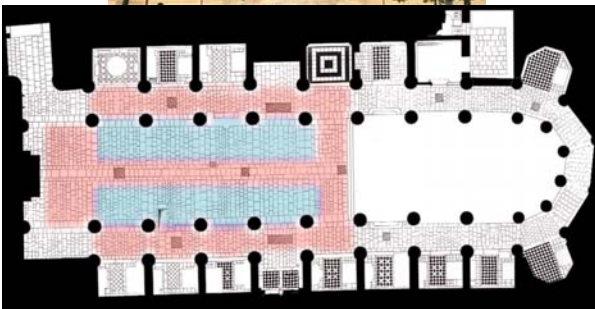


Fig. 4 – Cathedral Notre-Dame et Saint-Privat in Mende. Gothic architecture is complex, but the inner space remains rather simple and unified. The area covered by the installation is represented by the blue and pink zones. The only obstacles to the waves are the cylindrical columns. Geolocating the visitors was relatively easy. Twelve beacons on the columns, plus a main one suspended in the middle of the nave, were enough to reach a satisfying precision.

Fi network to localize the harmonic lanterns. Our beacons (or anchors) were fixed on the vertical surfaces of the church. In order to be precisely localized, a lantern must simultaneously be in the line of sight of four beacons. Then, in this system, all beacons had to be connected to a central beacon whose role was to probe alternatively the information coming from the other ones, and then to dispatch it to the lanterns for them to trigger the musical timbre associated with the wanderer's position. In this precise topology, we could not use more than twelve beacons without slowing down the system to a point where the music would be frequently interrupted. With such a small number of beacons, even if the spaces were geometrically simple, we had to undertake a trial-and-error process to determine the optimal position for each one. To make things less easy, each beacon had to be powered, and thus had to be not too far from an electric outlet – an element that is not that common in historical monuments. We ended up by covering about 85% of the space, leaving areas in which columns or other elements created “shadows” for one or two beacons. The localization in these areas was undergoing a progressive drift, in particular along the Z axis; but the precision came back to its best level as soon as the wanderer would go back in a fully covered zone.

Implementing the system in Chambord was far more challenging. A simple look at the covered spaces, which originally included all of the second floor and the double-helix staircase up to the ground floor, already reveals a complex, labyrinthian topology, with more than 50 different rooms or spaces organized around a wide central, cross-shaped hall. Moreover, the walls are thick enough to silent any electromagnetic waves at the frequency used by our system (the UWB Wi-Fi typically ranges from 1,9 to 2,9 GHz), so each and every room has to be equipped with its own beacons.

As mentioned above, we used a UWB Wi-

Considering the number of spaces to be covered (Fig. 5), using the same system as in Mende would have involved positioning and powering about 200 beacons. The cost of such a system would have been prohibitive, and the installation time unrealistic: powering a single beacon may require the secure installation of 4 to 12 meters of 5V-cable, which must be painted and/or hidden so as not to disturb the atmosphere of the monument.

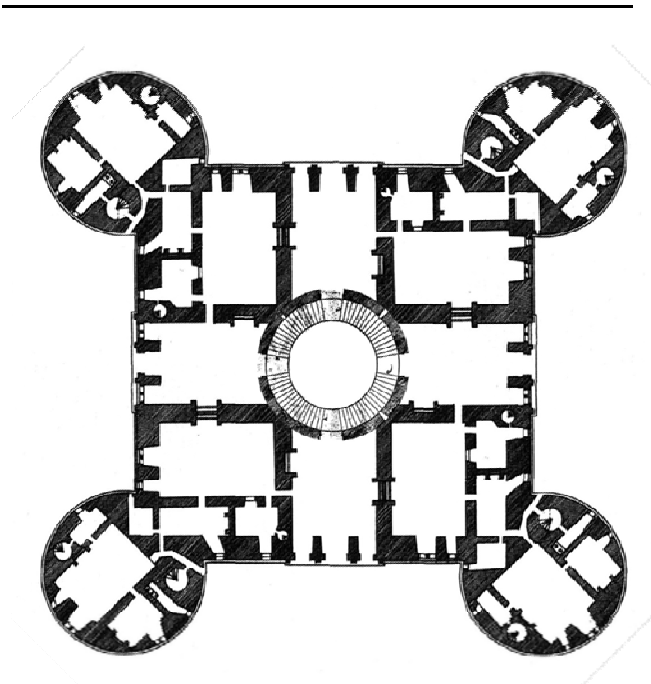


Fig. 5 – Plan of a typical floor at Chambord, according to the hypothetic original project by Leonardo. All elements follow a helicoid around the centre. The original staircase, represented here, has four flights between each floor, whereas the one that has been built has only two. The general topology of spaces is the same than for the final building, except that the two top towers are now mirrors of each other.

Our team then decided to develop a new positioning algorithm that would use the same equipment, but with a completely new tracking method. The main spaces, that is, the arms of the cross, would be

equipped with four beacons, just like in Mende. In these areas, the positioning would be as precise as it could be. All other spaces would be equipped with a single beacon. One beacon is not enough to locate anything, since it yields only a radial distance. In these spaces, the positioning would first rely on the information transmitted by this beacon, but it had to be assisted by two different algorithms. The first one computes the vector displacement from the last known precise position, by measuring the number of steps walked by the visitor, and the orientation of his displacement. This method creates a drift in the positioning, because of the errors inherent to each of these measurements, and because it relies on an average length for a human step; but as long as it is not used for too long, the results remain usable. The second algorithm is a collaborative one: it uses the lanterns that are carried by other visitors in the same room as relays to improve the precision of the position given by the beacon. It obviously relies on the presence of other lantern carriers in the room, and thus on the number of visitors. When this number becomes too low, an unused lantern can be temporarily installed in the room. Whenever the wanderer returns in one of the central halls, that is, one of the arms of the central cross, its position is recomputed with maximum precision.

By using these two algorithms, simultaneously or alternatively, we managed to track the position of the lanterns in all spaces covered by the installation with only 45 beacons, which is a considerable improvement from the 200 that were initially needed. Moreover, through this development, we could eliminate the need for a central dispatching beacon, which gave us more freedom for positioning all the other ones. After several days of trial-and-error and calibration, like in Mende, we could provide the visitors with the possibility to

generate fluid harmonic trajectories, despite the complex topology of the castle.

To our knowledge, this collaborative localization method has never been attempted before, and we are currently submitting first a paper to an engineering review. We are also evaluating the possibility to transfer this technology to institutions such as museums or arts centres, where its discretion and degree of optimization would undoubtedly be seen as major advantages over existing systems for position-based diffusion of information, or augmented reality systems.

2 – Larger Crowds

The second difference is linked to the potential number of simultaneous visitors. Though the Cathedral of Mende is classified as a historical monument, it is less known than Chambord. Located in a sparsely populated area of France, it also welcomes far less visitors than the castle, which has seen his frequentation topping one million visitors a year from 2017. Moreover, like all French cathedrals, Mende is still used for its original purpose: it remains an active place for all religion-related events. It is a very serene and meditative place; visitors and believers move and behave calmly and silently. From the very beginning, its ambiance was fully in tune with the contemplative nature of the *Point d.Origine* project. The atmosphere in Chambord is quite the opposite. The main function of the castle nowadays is touristic. During week-ends and holidays, crowds of visitors of all ages and countries regularly flood the spaces, walking at different speeds, entering and exploring everything, attempting to enter even places in which they are not allowed. Most of them express their appreciations and feelings at loud voice, talking to each other at a distance, taking selfies about everywhere. The presence of kids adds to

the general sound level, which is still amplified by the reverberation of the walls and vaults of the second floor. Such conditions make very difficult to concentrate on the musical experiment, and are rather stressful for the people in charge of distributing the lanterns and the headsets, providing the required explanations and charging the different devices. To cope with this situation, our first decision was to increase the number of lanterns: from twelve in Mende, we went to thirty in Chambord. We also had to hire two mediators instead of one: the workload would have been unmanageable for a single person.

Considering the noise level and the animation caused by the numerous visitors, we decided to explore the possibility to use high-quality, noise-cancelling headsets for Chambord. This decision proved fully successful. First, it allowed us to shift the volume control from the lanterns to the headsets, which had very interesting consequences at the design level (see below); but mainly, these devices immersed the visitors in a full and deep silence even before they began to create their own music. This silent period was seen by many as a welcome introduction to the music to come. The noise cancellation allowed the visitors to fully concentrate on the trajectories they were composing, without being distracted by parasitic or environmental noises. This is what is normally expected with noise-cancelling devices, but here, this function proved essential and salutary. Then another unexpected effect appeared. While wearing the headset, the wanderer would still be able to see the other visitors; but without the associated sounds, their movements and displacements, as fast or brisk as they could be, would transform into a strange, oniric choreography. The whole inner landscape of the castle became like a dream in which coloured silhouettes located at different distances

were wandering in front of a still background made of stone walls and sculptures - the only sound being the music composed by the wanderer himself.

3 – The Lanterns: the Eggs of a Mythical Salamander

The main physical modifications occurred at the level of the Harmonic Lanterns. After a first residency in the castle during the summer of 2018, we decided to introduce a design change that was not induced by the physical constraints of the Chambord environment, but rather by its symbolic meaning. One of the most famous kings of France, François 1er adopted as his emblem a common amphibian, namely the salamander, an animal that had at the time the reputation of being able to cross fire and flames without harm. Salamander representations are carved everywhere in the stone of the castle, from the façade to the walls and ceilings (Fig. 6). The vault of the second floor is made from square stone voussoirs on which sculpted patterns represent alternatively the capital letter F, for François, and dragon-like salamanders in different positions and attitudes.

We then decided to shape the lanterns in the shape of salamander eggs, just like if the visitors could receive them from the salamanders wandering on the arched vaults. It is worth noticing that the symbolism of the egg, strongly linked to the question of origins, adds a major layer of signification to the object itself, making it particularly fit for this very installation. The small lantern becomes the point in space by which everything happens, from the positioning of the wanderer at every moment at the centre of the musical and architectural cosmos, to the real-time generation of the harmonic trajectories. Each and every of its positions in space and time becomes the origin point for the visitor's experience.



Fig. 6 – A dragon-like salamander in one of the voussoirs of the arched ceiling, on the second floor. The salamander was the emblem of king François 1er, the founder of the castle. It was supposed to have supernatural powers, including the ability to walk in fire and flames without harm. The new Harmonic Lanterns were shaped to evoke the eggs of this batracian.

As we can see, though it was not critical for the installation to work, this change was directly induced by the new context in which the project was presented. It became one of the most important evolution steps between Mende and Chambord, not only because of the change it implied in the morphology of the lanterns, but also because of all the other changes that were introduced as a consequence of it.

For instance, the very concept of an egg-shaped object induces for the imaginary the idea of an elementary form. We thus decided to eliminate the spiral cable that connected the lanterns to the headset, and to transmit the musical timbres through Bluetooth protocol: the cable became to be seen as cumbersome, and as disrupting the simplicity of the egg-shaped lantern. As a consequence, all operations involving a manipulation of the devices, such as showing people how to

use them, or charging the different elements, were greatly facilitated.

Then, we could eliminate all controls on the lanterns by using the headset slider to control the volume. Since we could also eliminate from the embedded electronics the sound card that was required for the audio plug, we could notably reduce the size of the lanterns. As shown on the picture above (Fig. 3), the original ones were shaped as elliptic cylinders; the new version is ovoid with a different length along each axis, thus allowing people of different hand sizes to have an optimal grip on them (Fig. 7).



Fig. 7 – The new Harmonic Lanterns. Left, a completed Lantern. Middle, experiments in transparency for a Lantern shell. Right,

colour tests for three completed Lanterns. Shaped like flattened eggs with a silky texture, almost without any external feature, the Lanterns became abstract, intriguing objects that people loved to touch and handle, and were carried with a lot of care.

Then, in terms of pure design, everything was reconsidered, from the materials to the manufacturing method. Whereas the first lanterns were 3D-printed with a stereolithography apparatus, the new ones were molded in a urethane resin (the molds themselves were 3D-printed with a PFM device). The advantages of this technique are twofold. First, the lanterns became much more resistant to shocks and drops, because of the nature of the new materials. Second, we got much more control on their texture and appearance, thanks to the multiple possibilities offered by the available molding compounds and dyes.

The final lanterns look like slightly flattened eggs. Their material is of a translucent green, in order to evoke, as mention above, the egg of an amphibian. The inner of the shell is coated with a translucent layer of silicon acting as a dampening material in case of shocks, and as a differential diffuser, in order to smoothen the lights coming from the LEDs of the embedded electronics and to locally modulate the transparency so as to evoke a biological object. Then, the outside of the shell was sandblasted with a specific-size abrasive material, so as to produce a very smooth, silky touch, similar to the surface of a pebble stone washed by the sea for a very long time. Finally, because of the electronics inside, the lanterns were becoming warm while in function. Being able to carry a warm, egg-shaped, softly glowing object, physically disconnected from any physical device, while hearing the music it produces, gives an almost ceremonial stance to the artistic

experience, transforming the lantern into a precious object with mythological overtones that most visitors came to handle with a lot of care and attention.

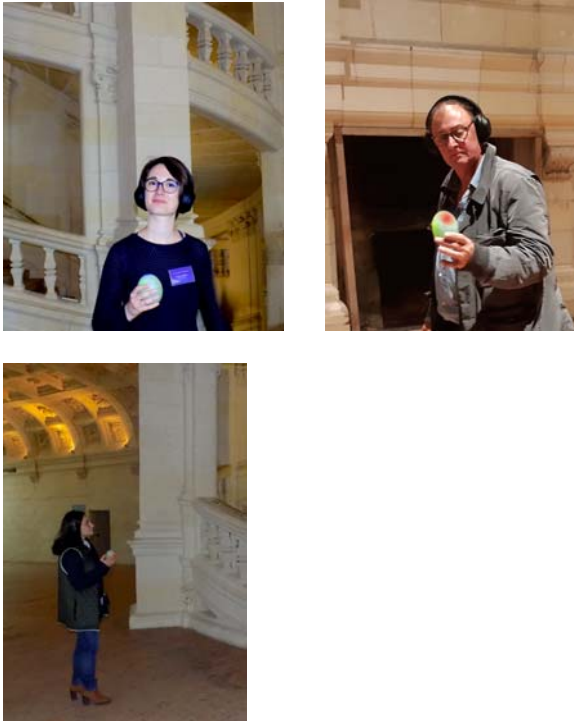


Fig. 8 – Experimenting the Point d’Origine installation. Left, Cécile Lavergne, one of the two mediators in charge of welcoming the visitors, demonstrates the use of the Harmonic Lantern and of the noise-cancelling headset. Middle, a visitor concentrating on the Lantern itself. Right, a visitor listening to the music generated close to the monumental double-helix staircase. In the background appear the arched ceiling, with its sculpted voussoirs representing alternatively the letter F, for king François, and dragon-like salamanders.

Conclusion

The Point d.Origine project rests on several layers of development, including architectural surveys, computer modeling, mathematics, physics, computer science, acoustics, design, musical composition, interface design. For the first installation in

Mende, the overall complexity of the project resulted in a system whose design and implementation were mainly determined by the harsh physical and technological constraints coming from about each of these fields: every decision was basically the product of a straightforward reaction to these constraints. Despite this almost functionalist research-creation path, the installation was welcomed with a lot of interest, and we could already foresee its evolutive path for a next presentation.

Chambord gave us such an opportunity. For this second version, about each and every element, software or hardware, material or immaterial, was rethought, reconsidered and redesigned so as to make for the challenges and influences coming from the environment itself, and to introduce features that were not only linked to practical or functional considerations.

Along these transformations, we realized that the required changes also had a strong impact on the way people perceived the installation. Though not infinitesimal, the physical changes undergone by the different devices remained minor. They nonetheless transformed considerably the way people would approach and appreciate the whole artistic experience. We could readily observe the changes in attitude and in the rhythm of the movements of those who were undertaking the exploration of the sound cartography of the castle, and the way they would progressively slow down their displacements, so as to harmonize them with the very contemplative experience provided by the harmonic trajectories, thus escaping for a brief moment the constant agitation and noise generated by the other visitors.

As for any experiment with this degree of complexity, everything was not perfect. Though the comments by the visitors and

the medias were unanimously positive, we were faced with new and unexpected difficulties that were directly linked to the new technologies that we had introduced, and which appeared only along the time of the presentation. In particular, the range of frequencies covered by our UWB Wi-Fi tracking system is very close to the frequencies used by cell phones. When the number of visitors increased, we encountered interference problems that could at time stop the music, creating for the visitors periods of silence that could last up to two minutes. We also had intermittent problems with the Bluetooth transmission from the lanterns to the headsets, most likely linked to a question of bandwidth.

These difficulties were not frequent enough to spoil the wanderers' experience, but we know we will have to address them for the next version of the installation. Since they seem directly linked to environmental constraints, they create the artificial equivalent of an evolutive pressure: solving them will amount to pursuing the evolution path of our adaptive system, and to generate, through new shapes and/or algorithms, a new *species* along the *Point d.Origine* genealogic trajectory.



Fig. 9 – *Point d'Origine* improvised choreography.

References

For a cosmological interpretation of Chambord, see, among many others:

[1] Fourrier T, Parot F - *Qu'est-ce que Chambord ?*, *Étude du décor sculpté et nouvelles interprétations*. Mémoires de la Société des Sciences et Lettres du Loir-et-Cher, 2010, Comprendre Chambord à travers son décor sculpté, pp.21 - 55. <hal-01194181>

[2] Monesti A – *La représentation du château de Chambord: imaginaire et réalité, mémoire* Master 2 CNRS, dir. Sabourin L, U. de Lorraine, 2012

[3] Reeves N - *From the Harmony of the Spheres to Spherical Harmonics*, PhD thesis, dir. Ascott R, U. of Plymouth, 2019.

[4] Vinci L - Manuscript A, folio 9, verso

[5] Vinci L - Manuscript K, folio 49, recto

[6] Reeves N - *Mende Cathédrale*, interactive musical installation, Mende, Lozère, France (cur. Artelozera, prod. NXI Gestatio), 07-10/2017

[7] Reeves N – *Point d.Origine*, interactive musical installation, Château de Chambord, Loir-et-Cher, France (prod. NXI Gestatio), 09-11/2019

Web Sites

[8] For the Mende Cathedral installation:
www.nxigestatio.org/NXI/MENDE-CATHEDRALE

[9] For Point d.Origine at Chambord:
www.nxigestatio.org/CHAMBORD

Notes

ⁱ Up to know, the fact that the double helix, which also symbolized for him the Tree of Life, is the same pattern that is followed by the structure of the DNA molecule, as discovered four centuries later by Franklin, Watson and Crick, remains at the level of a coincidence. But one never knows what to expect with Leonardo da Vinci, and the deep meaning of his intellectual fulgurances may well unveil in the future.

ⁱⁱ Here again, the fact that in the XXh century, special relativity described matter and energy as two different aspects of the same thing, and that quantum mechanics postulate that every matter or energy is associated with a wave of specific frequency, should be seen as simple coincidences, since the theoretical frame on which Einsteinian or quantum theories are built was neither existing, nor even foreseeable, at Leonardo's time.

ⁱⁱⁱ For instance, the two statements "The Sun revolves around the Earth" and "The Earth revolves around the Sun" are equally valid – i.e. "true" - in a relativistic Universe. If we decide to privilege the second one, it is only because the first one would make the equations of movement frightfully complex for all other celestial bodies. This simplicity principle is known as Ockham's razor.