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The Instrumentarium of Kircher: Premises of a Universal Phonurgy

Cécile Regnault

The Imaginary of a City-Instrument

Whether natural or built, rural or urban, outdoor spaces sound. Like concert halls, public spaces have acoustics, which can be compared to the sounding boards of musical instruments. Used to discuss urban ambiances, seminal ideas of a “city-instrument”¹ or *urban instrumentarium*² date back to times when acoustics, which was not yet a science, already fueled the sounding imagination of scholars. The hypothesis of instrumentation supported here argues that the sounds of our environments cannot be studied outside the architectural and symbolic contexts that shape their expression, and hence their understanding. Indeed, the etymology of the word *akustike*, which means “to hear,” reminds us that acoustics is a science that deals not only with properties of production and dissemination of the physical phenomenon but also with those relating to its reception, requiring systematic questioning of the conditions of perception. Therefore, we can argue that the complexity of acoustic knowledge was nurtured throughout the centuries by an auditory imagination that influenced our perception and its space-sensitive impact. Based on these hypotheses, this article explores the extraordinary freedom of the sound inventions proposed by the German Jesuit monk Athanasius Kircher (1602–1680), author of the first acoustics treatise in the West, *Phonurgia Nova* (1673),³ which was published in the second half of the 17th Century, a turning point for the advent of modern science.

By proposing a new phonurgy, this illustrated *in folio*⁴ book reveals the design of a sounding city, through a series of perfectly situated acoustic experiments, for example the engraving presenting the phenomenon of natural echoes based on a site’s topography, or that of artificial echoes triggered by configurations built based on precise dimensions and distances⁵ (Figure 1).



Figure 1: Natural echo – Wall of echo [Kircher, 1673, p. 41 & 47]

One could presume that the “phonurgic” postulate was a prelude to a certain aesthetic of acoustics, which is nowadays supplemented by two closely related concepts, the theory of ambiances and the aesthetics of atmospheres. The theory of ambiances, which is based on a phenomenological approach, was initiated fifty years ago in France by the Cresson team, founded by the philosopher Jean-François Augoyard.⁶ According to him, sound ambiance is a phenomenon located at the crossroads of three polarities: the physical frame that shapes the acoustics of the space, the sound practices that interact with that frame, and the feelings elicited by that meeting.⁷ In a recent paper retracing the ambivalence of the concept, the sociologist Jean-Paul Thibaud⁸ showed that the theory of ambiances was enhanced by the aesthetics of atmospheres, a more pragmatic approach, whose main initiator, Gernot Böhme, managed to launch an inspiring international school of thought for many architects.⁹ Regardless of the contexts in which atmospheres are deployed—natural milieus or artificial environments, public spaces or private spaces, theatrical scenographies or museum facilities—these contexts, according to Böhme, generate spatial qualities that offer living beings the immersive feeling that they belong and exist.¹⁰

To support the affiliation between the 17th-century treatise and the two 20th-century theories, I will first reaffirm the unprecedented character of Kircher’s book regarding the advent of a new science: acoustics. I will briefly recall the impact of the historical context at the end of the Renaissance on the polymath’s prolific work, and I will then explain how his metaphysics was the initiator of what we nowadays call pragmatics of sound ambiances, meaning an approach that is based primarily on active hearing of space through concrete sound experimentations. Throughout the article, I will be guided by the graphic expression of the treatise’s engravings, which solidify my hypothesis of the “city-instrument.”

An Unprecedented and Pioneering Acoustic Treatise of a New Kind: Phonurgy

Considered in his lifetime the “Phoenix of Scholars,”¹¹ Kircher was curious about everything. He wrote an impressive number of wonderfully illustrated books on a wide array of fields: astronomy, optics, geology, music, magnetism, hieroglyphs, alchemy, the Kabbalah and acoustics. Rather than the accuracy of the explanations of physical phenomena—his commenters indeed point out that he was not up to date with the contemporary scientific advances—it is the sum and diversity of knowledge which makes these writings a precursor to multidisciplinary. The historical interest of this first treatise of acoustics does not lie in the accuracy of the scientific demonstrations, but rather in the invention of instruments or sounding machines that suggest an experimental spirit based on praxis rather than on a logical-deductive approach.¹²

Therefore, it is not by chance that the late publication of *Phonurgia* within the scholar’s body of work gives a prime position to iconography. Written in scientific Latin,¹³ the *in folio* provides suggestive drawings of a rare graphic quality.¹⁴ Following an innovative practice at the time, the drawings were directly incorporated into the body of the text. More than mere illustrations, these architectural representations are precise enough in their geometry to show the acoustic impact of the “sound devices” on the overall perception of a territory. For example, the map of acoustic lines (Figure 2) shows the length of the acoustic distances between different horns and a network of villages several kilometers apart. Simple lines trace the directions of the sound waves.

Therefore, after the publication of *Musurgia Universalis*¹⁵ in 1650—which is considered a textbook largely full of mathematical models applied to music¹⁶—we can affirm that the late publication of *Phonurgia Nova* (1673) complements the musical theories of the time by extending them to the outside sound world. The transition from music to phonurgy is doubly original. On the one hand, the treatise was based on a wide spectrum of applications, encompassing every notable auditory phenomenon, without making distinctions between natural sounds, voices or music. It thus prefigures the theories of Concrete Music (*Musique Concrète*). According to Jean-François Augoyard, “phonurgy is the sound universe. It is the world re-thought, built from the sounds. It is not a simple metaphor.”¹⁷ Linking his argument to the pioneering results in sound ethology, the philosopher tries to define the sound ambiance of a place, insisting on a necessary detachment that can free one from the categories and value-based judgments attached to the different types of sound sources. On the other hand, sounds act jointly on the real construction of the environment, the representations of sound space and the symbolism of places, as shown in the map of sound territories [Figure 2]. This reasoning offers the first argument for my hypothesis of the city-instrument: the atmospheric space¹⁸ of the engravings is suggestive of its acoustic performance, foreshadowing in a way the schematic elements of a contemporary theory of atmosphere.

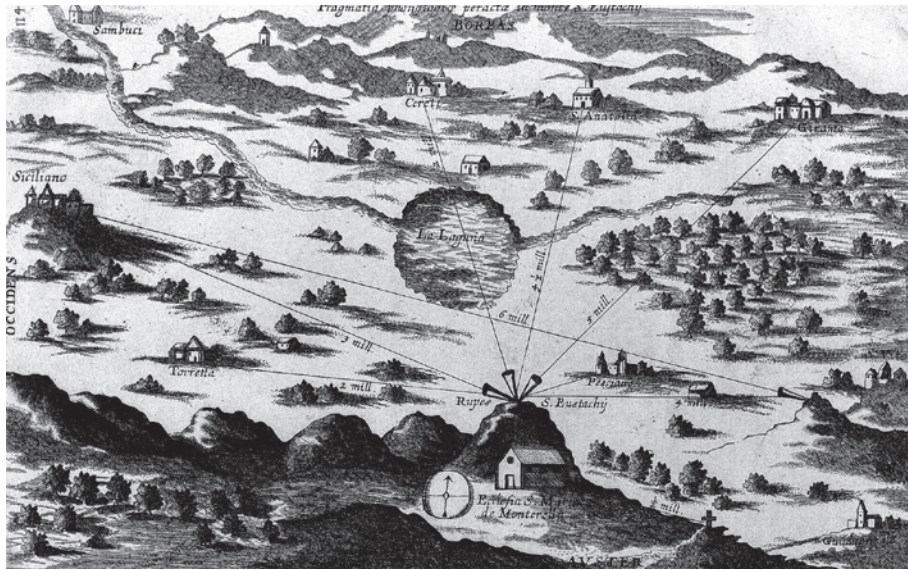


Figure 2: Map of acoustic lines between “talking horns” [Kircher, 1673, p. 141]

At the Limits of the Analogy between Optics and Acoustics

Studying Kircher’s engravings means looking for the unity of scientific fields, in this case the analogy between optics and acoustics. It is worth recalling that in the 17th Century, acoustics was not yet an established and independent science, but it could be defined as an applied one, in which empirical knowledge on the propagation of sound was used not only to explain musical harmony, but mainly to build instruments. This period also signals a break in the understanding of vision: the physiological parameters attributed to the eye are abandoned in favor of understanding how light works. The *camera obscura* became the absolute model for the eye. Taking for granted that sounds “mimic” light, Kircher applied the laws of optics¹⁹ to acoustics by using the analogy of how beams of light are reflected off surfaces. He borrowed the principles of the Snell-Descartes law, which describes the behavior of light at the meeting point of two milieus, and applied it to sound beams. This transfer from the laws of optics to acoustics, still used nowadays in simplified models of so-called “geometric” acoustics, is valid in certain conditions.²⁰ While geometric acoustics is good at explaining the behavior and reflection of sound waves when they come into contact with surfaces, the arrows symbolizing how the sound propagates inside the acoustic horns can be

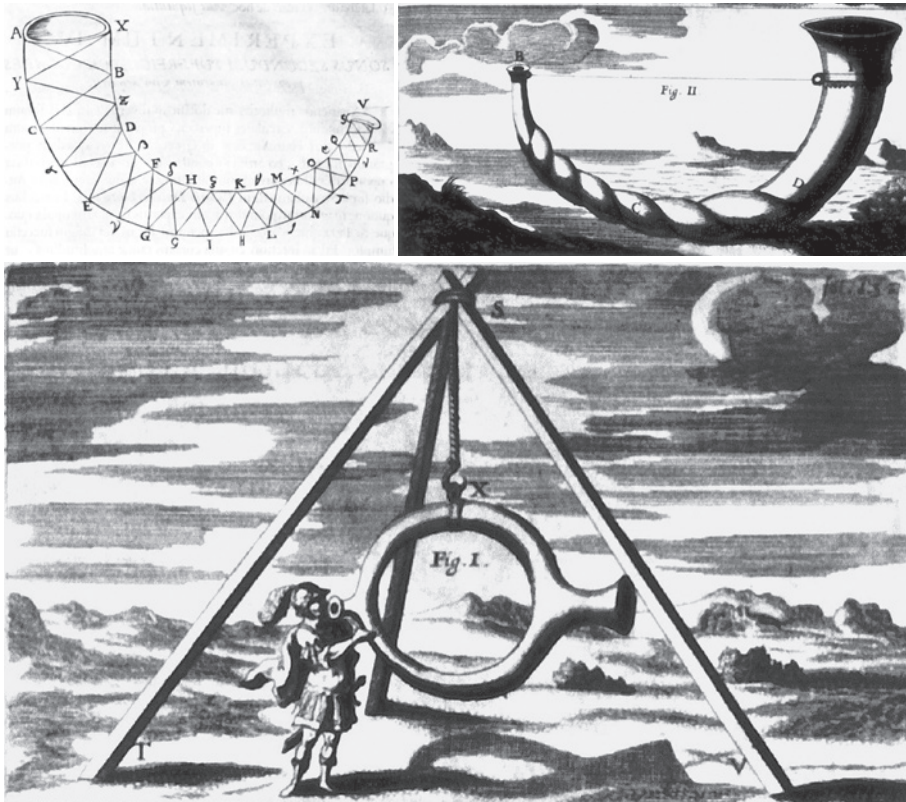


Figure 3: Incorrect diagram of sound propagation in the horns [Kircher, 1673, p. 67]

Visionary drawings of megaphones [Kircher, 1673, p. 133]

wrong in terms of their details but not in terms of the general principle of a horn on the scale of the landscape (Figure 3).

Kircher was convinced that the voice was conducted better through curved horns than through straight ones. The graphic aesthetic of his cross-sectional drawings nonetheless did not account for the phenomenon of vibrations. In the absence of a theory on vibrating objects²¹ (which emerged only at the end of the 17th Century),²² Kircher's explanations of physical phenomena are thus not always scientifically valid and are mainly conveyed by simplistic images accompanied by a text that is more descriptive than demonstrative.

Metaphysics Grounded in Myths: Metaphysics of the Living

As we have already mentioned, the treatise appeared at a turning point when acoustic science was emerging. Between empiricism and wave theory, the field of acoustics grew out of the observation of natural phenomena, such as the echo [Figure 1] and the symbolic image an echo conveys. Kircher developed in particular esoteric theories (imaginary mechanics) of the echo effect, which he tried to explain by using inaccurate distance ratios. It is mainly due to the verbal and written dissemination of Ovid's myth of the nymph Echo that the phenomenon became common knowledge. As the acoustician Pierre Liénard explains, myths broadened the history of acoustics, leading to scientific experiments and finally to the fundamental discovery of the phenomenon of vibrations.²³

In its conception of the living and its sensorial manifestation, Kircher's treatise outlines this metaphysical connection. This kind of thinking brings him close to theoreticians who belong to an aesthetics of perception. Unlike his "modern" contemporaries (Mersenne, Newton, Galileo), who contributed to an understanding of acoustics as a rational science, Kircher initiated in *Phonurgia Nova* a conception of the field as being tied to the world of the living. In that world, the sounds from nature (wind, echo, water, etc.) are part of a cultural vision of the sonic universe in which humans walk alongside the divine. The drawing on the treatise's frontispiece, with its angels blowing air, is an explicit introduction to the scholar's religious cosmogony, which recalls Aristotle or Genesis.²⁴ If Kircher's work did not align with scientific progress, it is because it was celebrating the wonders of creation, the results of a "natural magic"²⁵ stemming from universal magnetism. Moreover, Kircher's fascination with the East, emphasized in remarkable drawings of Chinese gardens, is not unconnected to his sensitivity to sounds and lights, or to his interest in water machines or Aeolian harps. In a drawing representing such a harp, Kircher suggests that the force of the wind will be able to vibrate a set of strings at the heart of the device. (Figure 4).

By providing this biographic background, too often ignored, my intention is to demonstrate that Kircher's acoustic curiosities have been infused with metaphysics, a fact that opens up the possibility of studying his work in relation to the contemporary aesthetics of atmospheres.

Atmospheric Halo of the Engravings: Communicating Acoustics

Acoustics is one of the sciences that has left the fewest traces. Sound is stealthy, elusive. It disappears as soon as we stop producing it, and the reverberation of a room lasts only a few seconds. Above all, sound is also difficult to represent. According to Godwin,²⁶ *Phonurgia Nova* demonstrates a graphic inventiveness that is very close to

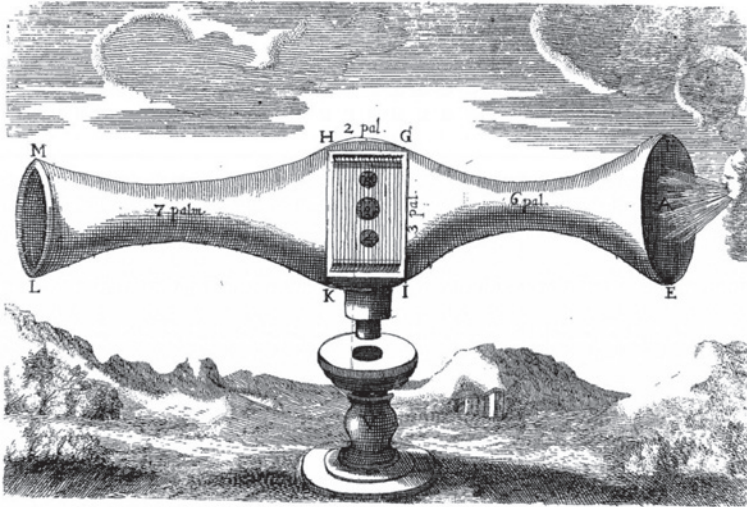


Figure 4: Aeolian harp [Kircher, 1673, p.144]

the scientific thought of the Renaissance period, which was not yet detached from an artistic and naturalistic vision of the cosmos. In line with Leonardo da Vinci's drawings, where art meets calculation, Kircher's treatise demonstrates that imagination can be as determinative as logical deductions are for humans. His refined perspectives convey the presence of weather phenomena, the change of scales of instruments, and are distinctive of a "technological and anthropological symbolism."²⁷ The high quality of the drawings and their technique, close to *sfumato*,²⁸ communicate an atmosphere in which the cosmos and divine presence are connected. The drawings represent true artistic pieces with a strong symbolic value: to convey an auditory world while representing nature as precisely as possible. For example, in the engraving of an Aeolian harp [Figure 4], Kircher proposes an "acoustic curiosity" that uses wind power to highlight the rustling sounds of the natural environment. Its scale and its position within the landscape express the unrealistic character of this curiosity. Trévoux's dictionary (1771) offers three words to define a curiosity: *curiosus*, *cupidus*, *studiosus* – attention, desire, and passion for knowledge. Even in its late period, the Renaissance represents the golden age of curiosities. Indeed, many pages of Kircher's treatise present acoustic curiosities in scenes in which angels fly and the divine power blows through the windmills, as proclaimed in the frontispiece. Such an approach underpins the thesis of the imaginary power of legends told through these images: they thus work to represent the sensory world in which such auditory experiences and acoustic performances could be opportunities to make scientific progress.

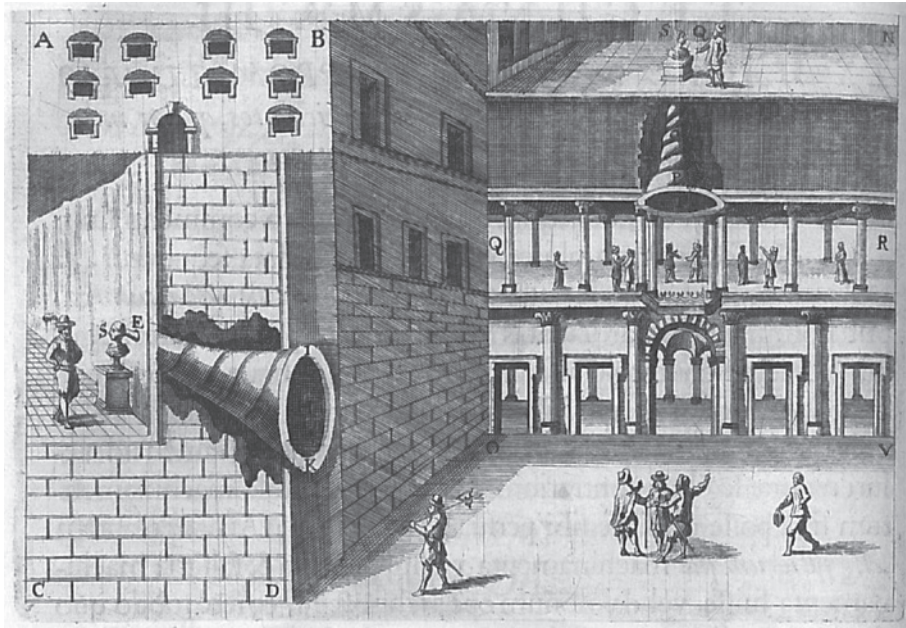


Figure 5: Talking Statues [Kircher, 1673, 162]

In the engraving called “Talking Statues” (Figure 5), the precision of the architectural drawing does not prevent the imagination from considering the humans’ position in the world, as they listen to their environment. The outdoor space of the square, as well as the interior space of the building, are represented as resonant bodies inhabited by the human voices that pass through them. In the same image, Kircher captures shifts of scales and meanings: the buildings include original devices built into their walls (talking statues, auditory canals) that are similar to ancient horns and trumpets. The classical modes of architectural representation (perspectives, axonometry, sections), which describe precisely the geometry and nature of the materials, also demonstrate innovative sound practices. They suggest vocal exchanges between the inside and the outside, recalling the communicative power of such devices. Therefore, the different elements present in this engraving are part of the definition of what we nowadays call sound ambiance:²⁹ the physical framework of architecture, sound practices and the feelings conjured by the scene.

This image bolsters my second hypothesis by considering empiricism as a source of innovative experiments to study sound in architecture. Architects are interested in these acoustic curiosities because they connect to the construction of machines, in which experience denounces the artificial separations between the subject and the

architectural object in line with the contemporary theories of atmosphere³⁰ or ambiance.³¹ Kircher's thinking belongs to a time when there was no dichotomy between art and science, when music and acoustics were one. Artistic creations and scientific demonstrations lived side by side within modes of experience in which not the object but hearing is conjured, meaning the relationship between the "hearing subject" and the "sounding object." In this model, sound does not exist independently from the space that makes it ring or the listeners. Sound and sounding space blend together. Hearing predominates.

Furthermore, sound phenomena are considered within the totality of their spatial context of propagation and reception: wind, echoes against the walls or propagation inside pipes. Contextualized sound phenomena deal with both the aesthetics of composition and a form of pragmatism, in which sensory experiences and the observation of phenomena guide their interpretations. At no point does Kircher's thought try to objectify sound or turn it into an "object," since it is close to an existential conception of technical objects, as also defended by the philosopher Bruno Latour.³² The "Talking Statues" [Figure 5] are like auditory windows on the environmental sounds. The "Aeolian Harps" [Figure 4] are the signals of weather events perceived by all of the senses. In these examples, empirical experiences lead to the invention of a novel form of music instrument making and a way of considering anew the permeability of architectural envelopes, in which classic windows appear to have the capacity of genuine hearing.

From Curiosity to Acoustic Utopia: Images Witnessing the Sounding City

Lastly, I would like to emphasize the formal aspect of the urban *instrumentarium* described by Kircher. *Phonurgia Nova* is the culmination of a lengthy work on musical lutherie.³³ Kircher changed scales and transferred, even without accuracy, the acoustic principles of musical instruments to the built space: he imagined acoustic pipes and horns at the scale of architecture, city and landscape that were conceived homothetically and accompanied by geometric diagrams. Moreover, he made sure that this system was reversible. Was he the first to invert the function of horns, trumpets and other wind instruments, emphasizing not the emission of sound but the reception of sound by the ear? Before instrument-making, seashells and animal horns were undoubtedly the first objects used by humans to enhance their hearing. In Antiquity, sailors and fishermen in the Mediterranean used whelk shells as horns. While historians do not mention the importance precedence of such inventions, in medicine, the physician Renner³⁴ considers Kircher to be a pioneer in the description of ear trumpets. Inspired mainly by wind instruments, Kircher "reversed" their function.

It is hard to tell if Kircher had the opportunity to really test out these curiosities. He might have simply been inspired by sound devices that he had seen or heard in gardens during his travels. The visionary drawing of megaphones [Figure 4] depicts the delicate passage from acoustic science to the concept of sound culture. Kircher used his purely geometric demonstrations of the propagation of sound inside the horns to convert them to a megaphone's dimensions, ten times larger. Re-drawn on the scale of a large open site, these instruments, "catapulted" into the landscape, suggest the desire to overcome the natural powers of the ear in order to allow it communicate easily over a distance, like the hearing devices developed by military staff in the 20th Century during the two World Wars, in order to hear from afar and send signals between camps. These large acoustic horns demonstrate the broadening of knowledge from musical lutherie to the emergence of a soundscape culture. On the architectural scale, Kircher used pipes or giant acoustic horns to reveal the sound porosity of walls, between the building and the city, as well as between the city and its underground levels.³⁵ While such representations must be considered cautiously, they demonstrate how instrumental lutherie can resonate with urban morphology. As such, there is an instrumentation taking place in the proper sense of the word, between the sound effects of the drawn instruments and the built space of the city. For example, in another engraving, the shape of a new instrument imagined by Kircher refers to the profile of church bells, which can be considered the oldest instruments of our cities.

Whether we study Kircher's cross-section of the bowels of the earth, the ear trumpets in a building, or the megaphone drawings, all these images indicate a sensitive imagination that does not distinguish the utopic from genuine acoustic inventions. Among technical utopias, Kircher's *instrumentarium* is unique, particularly because of the diversity of acoustic scales involved. From the musical instrument to the landscape, via architecture, Kircher aimed to represent nature with as much accuracy as possible, like a miniature world where sounds have their place.


Conclusions

Very often reproduced but rarely situated in their metaphysical context, the *Phonurgia Nova* engravings have been cited for their extraordinary evocative power. Presented to contemporary eyes, they become visionary objects of the history of science, images that serve as witnesses in the history of acoustics while resonating strongly in our ears, which are overwhelmed by our noisy environments that never seem to quiet down. Beyond the fact that these acoustic curiosities expressed a creative vision of acoustics as a science, they remain, four centuries later, fertile imaginary resources for the architects and sound designers of our time. The reason is that these acoustic curiosities explicitly draw our attention to the importance of listening to space and qualifying

the sound exchanges between indoor and outdoor environments. The other prominent element of the treatise is the crossing of different scales, varying from body-sized “sounding objects” to sound sculptures integrated into the landscape and architecture, by way of spatial devices incorporated into buildings. The convergence of environmental, architectural and acoustic data represents an alternative approach to the contemporary design of the city suggesting a synthesis of sound arts that requires collaboration between musicians, designers, acousticians, landscapers and architects. Indeed, to conceive the atmosphere of a place, the manufacture of sound space naturally requires the project management teams as well as the design teams to transcend scales. Finally, beyond Kircher’s ability to combine the scales of sound, the universal phonurgical thought of this great scientist of the end of the Renaissance testifies to a tension between science and philosophy, between empirical analysis and myth, between sound as an object and listening, as something that was lost in the normative practices of the academia during the European Enlightenment. As a consequence, Kircher’s treatise invites us to imagine and animate the necessary interrelation between different professions, useful in the invention of sound atmospheres.

Notes

1. Cécile Regnault, *Les représentations visuelles des phénomènes sonores. Applications à l’Urbanisme*. Université de Nantes: Thèse de doctorat, 2001.
2. Jean-François Augoyard, “Un instrumentarium urbain,” in *Urbanités Sonores*, Michel Grosjean and Isaac Joseph (Paris, 1989), 14. <https://hal.archives-ouvertes.fr/hal-02104257/>
3. Athanasius Kircher, *Phonurgia Nova* (Kempten: R. Dreher, 1673).
4. In the 17th Century, *in-folio* were usually very big – 10 kilograms per book – reference books and were close to our modern A3 format.
5. Measurements that will prove to be wrong.
6. Jean-François Augoyard, “Éléments pour une théorie des ambiances architecturales et urbaines”, in *Les Cahiers de la Recherche Architecturale*, 1998, 3 (42–43), 7–23.
7. Jean-François Augoyard, “L’environnement sensible et les ambiances architecturales”, in *L’espace géographique* 4–1995, 310.
8. Jean-Paul Thibaud, “Petite archéologie de la notion d’ambiance”, in *Communications: Les Bruits de la Ville*, 90–2012, 155–174.
9. Peter Zumthor and Philippe Rahm, two contemporary architects and defenders of the concept of atmosphere.
10. Gernot Böhme, “Atmosphere as a Fundamental Concept of a New Aesthetics”, in *Thesis Eleven*, 36–1993, 113.
11. Sylvain Matton, *Kircher Athanasius – (1602–1680)*, *Encyclopædia Universalis*.

12. For example, the second edition of his treatise on light re-use principles of the magic lantern. The adjective “magic” corresponds to Kircher’s metaphysics, depicting the spiritual and evil dimension of science.
13. In the Germanic part of Europe, where Roman law was in effect until the end of the Empire, Latin remained for a long time the language of important scientific publications in order to be disseminated across Europe.
14. The precision of the line is possible with the technique of copper engraving.
15. *Musurgia Universalis* (1650) is by far one of the most comprehensive syntheses of musical knowledge at the time.
16. As part of scientific knowledge on music, we can mention the theory of vibrating strings, known by the Chinese, or the struck plates already observed in ancient civilizations.
17. Jean-François, Augoyard, “Expérimenter et analyser un parcours de phénomènes sonores,” in *Hors les murs*, n°8, janvier 2013, 5. <http://www.rueetcirque.fr/app/photopro.sk/hlm/doclist#sessionhistory-7RDIOtZ3>
18. Including both people, built spaces and nature, according to Böhme, 1993, 114.
19. In *Ars magna lucis et umbrae* (1646), the summation of proto-scientific and artistic theories from the observation of light and colors (*chromocritica*), Kircher developed the evil (*magia*) part of geometry and optics that were practiced according to empirical processes from the 16th Century in Italy (Matton, *Encyclopedia Universalis*).
20. The geometric method remains valid, provided that the wavelength does not exceed the dimensions of the obstacle.
21. This theory consists in no longer modelling sound as a simple beam but as a variation in air pressure from an issuing body.
22. Theory published by Huygens in 1690.
23. Pierre Liénard, *Petite histoire de l’acoustique. Bruits, sons et musique* (Paris: Lavoisier, 2001).
24. Jocelyn Godwin, *Théâtre du monde* (Paris: Actes sud, 2009).
25. Ibid.
26. Jocelyn Godwin, *Athanasius Kircher: Un Homme de la Renaissance à la Quête du Savoir Perdu* (Paris : Homes and Hudson, 1980).
27. Ibid.
28. The word originates from “*fumare*” in Italian, which means “misty.” It is a painting technique conceived by Leonardo da Vinci. It represents the effect obtained by superimposing several delicate layers of paint, which give the outlines of a subject an evanescent aspect.
29. Brice Begout, *Le Concept d’Ambiance* (Paris: Seuil, 2020).
30. “We are not sure whether we should attribute them to the objects or environments from which they proceed or to the subjects who experience them.” Böhme, *ibid.*, 114.
31. Augoyard, “L’environnement sensible et les ambiances architecturales,” in *L’Espace Géographique* 4 (1995), 302–317. 

32. Latour. *Enquêtes sur les Modes d' Existence: Une Anthropologie des Modernes*. (Paris: La Découverte, 2012).
33. *Musurgia Universalis* (1650) is by far one of the most comprehensive syntheses of musical knowledge at the time.
34. Renner. "Sur l'histoire des cornets acoustique," in *Annales françaises d'Oto-rhino-laryngologie et de Pathologie Cervico-faciale*, Volume 129, Issue 1, (2012), 75–81.
35. Kircher's intuitions were applied for the first time in the 18th Century with the sound tubes of military buildings used to communicate from one blockhouse to another, as well as with the phonic pipes set up on ships. The sound tubes used in castles and large houses, described in the monk Dom Gauthey's memoirs, could reach dozens of meters to carry orders to the domestic servants. Initiated by physicians, the construction of sound horns and tubes appears to be later than the 18th Century. It stopped in the second half of the 20th Century with the closure, in London in 1962, of FC Rein & Son, the most emblematic manufacture of sound horns (cf. Renner, *ibid.*).