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EXPERIENTIAL ACOUSTIC'S TEACHING FOR ARCHITECT

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ABSTRACT

This paper makes a critical return of 15 years of teaching acoustics to student architects. Learning acoustics through experience and experimentation is the philosophy developed at the National School of Architecture of Lyon. The experiment starts with listening to the world. Learn to be attentive to all the sounds of our daily environments. This first step involves separating things between the perception and the analysis of measurable acoustic data. This type of knowledge is supported by repeatable experiments and measurement protocols in time and space. This includes workshops, blind soundwalking, acoustic measurement, sound recording, editing and rendering in soundpostcard. The exercises offered to students are akin to experiments to transform the acoustics of an existing place (manufacture of sound models, modeling can complement the graphical tools of geometric acoustics). The teaching method will be primarily experiential learning. Emphasis will be on supporting students to develop a balance between technique, intuition and creativity. Finally, learning can involve the concrete realization of constructive prototypes whose specificities we can measure (luthery objects, music kiosk, acoustic conch) that allow the student to confront the fact and the iteration between this knowledge and the audible results.

1. LISTENING AS A SPACE EXPERIENCE

When you teach acoustics in architecture schools, you deal with the obstacle of eye's primacy. The Your first priority is therefore to develop a listening attention to deconstruct retinal habits of architects inherited from visual representations inscribed in the history of architecture reinforced at Quattrocento by the invention of perspective which fixes a point of view. The main issues being to demonstrate that the two senses do not oppose but complement each other.

Listening is a way of seeing architecture better. It requires an experiential pedagogy. The experiment begins by listening to the world we live in. The various methods of exploration are all anchored *in situ* : search for singular hearing points, contemplative listening, blind journey, detection of sound effects, wiretap, instrumented walk ... These different techniques for approaching sound space go beyond the mere moment of discovery and invite you to immerse yourself in long observations, accompanied by notes, drawings, readings, sound recordings, etc.

¹ This situation is becoming familiar to students with the increasing use of non-synchronous audio-visual equipment in apprenticeships.

This can be achieved by the production of a narrative captured on the spot, as the manner of the ethnologist's notebooks, sensitive maps, field recording or carefully prepared sound samples to produce sound postcards. These different forms of representation are the first acts by which the sound exploration of space is sedimented into formed knowledge capable of being shared. Starting from these own experiences to build an audible reference system. This is the essence of this so-called experiential pedagogy.

2. BLIND WALKING

2.1 Story



Figure 1. Blindwalking, convent of la Tourette, 2015.

If there is one area where the acoustic method has proved its worth, it is indisputable that hearing is to pedagogy what painting owes to sight.

Known since antiquity with the famous courses that Pythagoras dispensed behind a curtain, the acousmatic situation offers several advantages. Not seeing the teacher would increase listening attention and therefore learning efficiency. Beyond the situation of speech given by hiding the speaker and his mimics¹ the method is particularly efficient, when the subject learns to listen to his environment.

The deprivation of sight's sense automatically increases the attention towards the other senses and places the subject in a situation of acute acuity, refining is hearing ability. This didactic intuition is today largely supported by neuroscience research on multi-processsensory effects present in the brain, including the demonstration of the

functional interdependence of modalities and their functional equivalence and adaptability.

The anthropologist David Howes reports “it is now certain that regions specifically attached to one direction can be “recruited” or reorganized by other regions specifically attached to another direction in the case of sensory deprivation, such as visually impaired or deafness. For example, the visual cortex of the blind may exhibit activity during auditory tasks, while the auditory cortex of the deaf may be activated by visual tasks” (Howes, 2010, p.38). This brain intermodular plasticity defies the conventional sensorium model, with five distinct structural and functional modalities. This more “productive model for conceptualizing processes of perception” (Howes, p.38) is close to the synesthesia¹ phenomena that Howes analyzed in his ethnographic research. He gives the example of the people of Papua New Guinea where he found evidence of audio-olfactory synesthesia. Its findings transcend the field of neuropsychology and are contradictory to those of cognitive neuroscience (Stevenson and Boakes, 2004). Howes shows that the different forms of synesthesia involve links that connect the body, the environment and the social world together. To illustrate this phenomenon, he took an interest in synesthetic associations that the Desana² make with a certain kind of flute: “It is said that the sound of this instrument is yellow, has a warm temperature and a masculine smell. It is claimed that the vibrations produced remind people of the correct way to care for children. I emphasize that these synaesthetic associations are culturally shared and not reserved for the few idiosyncratic perceptions of a genetically predisposed individual (as suggested by the interpretation of synesthesia proposed by cognitive neuroscience)” (Howes, 2010, p.42).

Not willing to enter into disciplinary controversies, I simply wish to point out that the discoveries on synesthesia call for a further broadening of intermodality approach, by introducing the context of the spatial culture of nations observed. These scientific results can be compared to the practices of blind walks still called «white walks» which since the 1970s have permeated the environment of sound ecology. This type of exercise, developed with hundreds of students architects since 2001, strengthens the effectiveness of this method as regards the immediacy of emotions and the radicalism of the change of attitude that leads the student not only to an awareness of the importance of the sound dimension in the perception of space, but also an ability to name and remember perceived sound phenomena.

The sound that is both material and mental has no shape or weight. It cannot be touched. And yet my body is closest to him in this sound dance. The sound accompanies my body in space during the dance. It rhythms

¹ The first forms of soundwalk developed overseas offer variants that don't necessarily deprive the listener of vision: Max Neuhaus (1966), R. Murray Schafer (1977), Hildegard Westerkamp (1974), Andra McCartney and David Paquette (2011). This method is now being relayed by many sound artists.

my states of soul, my cadence, vibrates my body: the buzzing reassures me, the cut surprises me, the reverb disturbs me. Where am I? My senses awaken, at first they enlighten me and then as this dance goes on they trick me. Each sound is different, due to its effect, its nature, the space surrounding and my auditory memory (hence the different colors). It spreads to a certain point and mixes in space, the notion of time, of space, and the distance between me and the latter remains ambiguous.

Sound Dance Decressac Melissa³

2.2 Lesson from Experience

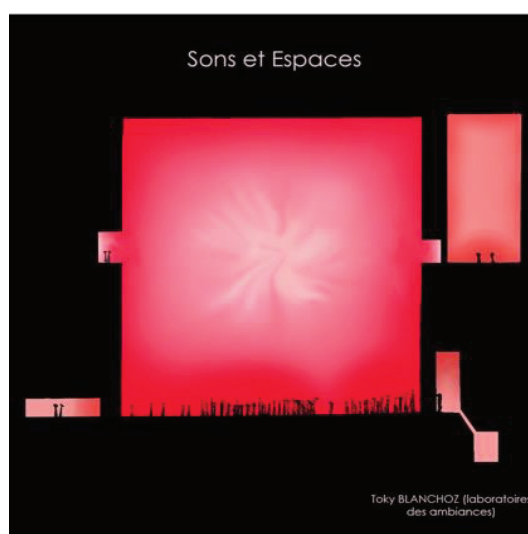


Figure 2. Graphic interpretation, Blanchot, ENSAL, 2017

The experience of these journeys always leaves traces in learners' memory. Deprived of sight, the ear sharpens its acuity. In a “fixed point of hearing” situation, the listener is able to quote without difficulty all the sound sources present only by ear. The method is particularly rich in positioning sources in space, highlighting the lateralization and depth of field of acoustic space. Logically, starting from a description of all that is close to the body and gradually widening to the most distant sounds, not seeing is revealing of real acoustic distances. In fact, seeing horizons can sometimes deceive the ear and influence sound perception; freeing oneself from the eye helps to hear better. If finality isn't listening without seeing, it's undoubtedly an important step to get the student out of his (her) comfort zone and to raise his (her) attention,

² People living in the Colombian rainforest and speaking Tukano dialect

³ Story of a student from the Ecole nationale supérieure d'architecture de Lyon. Laboratoire des Ambiances, Bachelor 2, Regnault, 2017.

especially to forge a vocabulary to name what he (she) perceives.

This auditory experiment of space is an essential prerequisite for acoustics courses: they take meaning in the daily experience of a lived sound and a perceived sound already expressed.

The Dominican brothers say they recognize Lyon's students by this peculiarity that they have to listen to the convent, to walk around blindfolded and then to record it rather than to look and photograph like the majority of their visitors. Listen to look better, ultimately to make understand architecture differently. This step aside, unusual among architects, has the merit of freeing students from the intellectual and scholarly shackles of Le Corbusier's architecture; of making this raw piece of modern architecture more fleshly. Sensory exploration is only possible if one takes care to prepare the body to open itself to all senses.

3. THE GREAT CRY

3.1 Story

La Tourette monastery, November 2012; as every year, for 5 years I have been experiencing *in vivo* the variations of silences and lights offered by the architecture of the Dominican convent that despite its tourist notoriety remains a place inhabited by a dozen brothers who continue to welcome visitors, cultural encounters, art exhibitions, while living their religious commitments. In a study residence for two days at the convent, the group of about thirty architecture students is immersed in the dark of the church. They read aloud and listen in turn to texts from opposite angles, several tens of meters apart. Instruction is simple: to experiment the space with the voice, by playing on their mutual positions of transmitter and receiver, their speech rates, the tone and the power of their voices. Placed at the ends of the large parallelepiped volume, they play and test the acoustic effects in the naked ear: effect of coupling with the crypt whose volume communicates with church space, effect of relocation. The demonstration of loss of intelligibility doesn't require scientific explanation. Repeated experiments are enough to make us understand what a very long reverb time means; without calculation and without prior acoustic knowledge, the effect is embodied physically by the diction exercise, which sometimes turns into a sung voice. Students have fun counting the seven seconds of reverberation ...

The session ends with a new experience for many: the ritual of the great cry. It breaks the previously imposed instructions of respect for the silence called for in this place. This detonating experience for any apprentice-

listener, I get it from an anthropologist friend who convinced me of his pedagogical virtues and accompanied several times to the convent to put it into practice. We ask the group to stand in line, like an orchestra in front of the conductor, who suddenly gives the order to shout as loud as possible all together. The effect is striking; the collective breath makes the air vibrate with such force that all the volumes are shaken by the sound energy that shatters on the walls. After 7 to 8 seconds of attention to the dragging of the sound, the return to silence takes on an extent that is not comparable to the one we could experience the students before their cry. The ears need a time of rest that everyone appreciates at its proper value, the faces relax, the smiles let us perceive the shared pleasure that the transgression of such a phonic gesture provides.

Cécile Regnault, *Le Grand cri*, Convent Church, 2014.



Figure 3. Earing collective experience, convent of La Tourette, 2014

3.2 Ear learning

Experimenting architecture by voice is not common in the training of architects. Following in the footsteps of architecture theorist Steen Eiler Rasmussen who encouraged his students less use the look to 'live the architecture', our first-year teaching team at the School of Architecture in Lyon (2008-2014) looked for entry into the sensitive learning of architecture: even before delivering knowledge books that risked to lock in dogmas sclerotic for creativity, the initiatory residence in Le Corbusier Convent offered the setting conducive to the discovery of the senses. Three days of immersion in convent life quite, different from a simple guided visit, in order to propose a living lesson of architecture.

The challenge was to immerse students into a prolonged sensitive experience, by sharing 62 hours of life with the Dominicans. The main purpose of this pedagogy is to test the ways in which the body moves and finds its place in such a space. Awaken bodily consciousness of space, make explicit, describe, draw, write to keep tracks; in this test of the ordinary, do not forget to make live exceptional moments to mark minds and rekindle memories. In short, this pedagogy had to put the student, during his first months of studies, in a position to become aware of the ordinary floating perception.

The pedagogical performance of the Great Cry was born in this context, with the primary objective of raising attention to the listening of the architecture, in order to raise awareness of the variety of acoustics, of the way in which one can collectively take possession of a place in the ear, to share a sound experience in order to compare one's listening to that of others. This experience came as a counterpoint to blind journeys and reading aloud, choreographies orchestrated around the building structural elements. I owe a great deal to anthropologist Patrick Romieu¹ for these techniques of "hearing" and "sound crossing": closing my eyes and turning on oneself to apprehend the 360 degrees of sound space, doing "antenna" with his body by extending his arms to touch the sounds as far as possible. These warm-up exercises, such as 'body postures of listening', dig into the space, spot latent silences that allow listening. This introduction prepares us for the great cry. It is a question for the pedagogue to set up a space-time of availability to listen through forms of rituals, ceremonies creating by the same micro-ephemeral communities of listeners.

The awareness of the existence of a possible listening space passes through several states: first feel the space in its globality, soak up the atmosphere, listen without seeking to objectively listen, put its ear to the alert to grasp all the sounds that would arise, focus on a singular form and listen to sound precisely in its duration, in its spatial deployment, then apply itself to hearing while seeking meanings and finally understand how the sound space functions in its unity, its continuity, its variations and its strata why it sounds so. The didactic challenge is to make an impression on people's minds, to ensure that the trace of the gesture accomplished can, by way of a backlash, activate more durably architects hearing sensitivities?

Today I see how the experience of the Great Cry² was foundational in order to bring about in the learner-experimenter an indispensable state of presence to understand the place. In this, the La Tourette convent church is a case study more than conducive to the necessary immersion that this experience demands; with these 7 seconds of reverberation time, this emblematic architecture is a sensory facilitator that facilitates the awareness of its spatiality and acoustic volume. Pedagogical success is also due to the transgression of shouting in a place of worship where the tacit rule is to remain silent. In hindsight, I suppose that if the great cry is effective in awakening the senses it is because it is in some way reminiscence, in a collective form, of the birth cry; it is an archaic gesture, a way to fix the first and subjective experience through a shared bodily performance.

¹ He didn't write himself a text about this practice that I learned with him through experimentation. He was quoted by sociologist Valerie Lebois who invited him on several occasions to the Strasbourg Architecture school and synthesized his contributions in the proceedings of the Symposium *Ambiances tomorrow*, held in Volos (Greece) in 2016 and to which the reader may refer (in Rémy and Tixier (eds.), 2016).

² The teaching as it was conceived collectively disappeared during the redesign of the programs in 2015; I transposed the exercise in the atrium

4. ACOUSTIC EXPERIMENTS

“Experimentation is a tool, a scientific method that requires the systematic use of experience to test hypotheses and gain positive knowledge in experimental sciences³.”

4.1 From experience to experimentation

The word “experimentation” has two meanings in French. Or its specifically refers to the action of experimentation: its a field of experimentation, can be applied to both scientific and humanities disciplines. Or it indicates a probation. In a more specialized sense, experimentation refers very concretely to an experience provoked in order to observe its results. The word is thus attached to the birth of modern science (17th century) and commonly referred to the elaboration of a called experimental method, which would result in a consideration of experience, by the observation of phenomena and the recourse to experimentation.

Historically, experimental approach as tool of knowledge of real world was introduced at the end of sixteenth century. From the lived experience we have, we move to a proactive form of experience we make; an act of representation that underpins some form of knowledge of the world, or even scientific models that guide the protocols of experimentation: testing hypotheses, application of a theoretical framework defined as a paradigm, source of innovation to be completed. The word 'experimentation' calls for situations less spontaneous than experience: precise protocols are built upstream.

4.2 Play with unintelligibility

In pedagogy, we can extend the notion of experimentation to creative performance. I use to introduce resonance and intelligibility⁴ notions with one of the 20th century greatest sound art manifest: *I am sitting in a room*, due to Alvin Lucier. This video performance (play for voice and magnetic tape)⁵, which exploits the looping of a sound recording, turns the notion of intelligibility into “derision”. The American artist experiments sound space with his voice. He pronounces a sentence, which will be heard and heard for more than an hour through a decisive acoustic and perceptive experience. Introducing the reverberation acoustic effect into composition principle was then a real novelty. This sentence is pronounced only once, then the words are reinjected into loops gradually increased by their own resonances. After a dozen repetitions, the meaning is already erased in favor of warm-cold waves, which become hypnotic. Further on, the harmonics add up and reveal the richness of a pure sound that the mixed convolutions carry, eroding the notion of time and even the idea of repetition, which is here the action motor. Space

and the inner street of the school of architecture of Lyon, which has an important reverb even if the symbolic impact of the transgression is less.

³ CNRTL, accessed June 17, 2017 (<https://www.cnrtl.fr>).

⁴ Considered as primordial sound quality factor in the majority of human-inhabited architectures, speech intelligibility is a master parameter that acousticians measure according to different methods, the most common being RASTI methods.

⁵ The first performance of the work was in 1970 at the Guggenheim Museum in New York.

acts as a filter. What we hear are therefore the room natural resonance frequencies, articulated by speech. Halfway between artistic performance and scientific experimentation, this piece expresses the essential transition from intelligibility to unintelligibility. She was able to make my architect memory as to how sound is shaped by architectural space. On the other hand, it's the artist's voice that reveals architectural space, because without it, it does not exist. Through its form, its geometry and its materiality an acoustics is defined that influences and transforms endlessly the sounds emitted in space. The resonance scientific principle are transmitted by a thorough and commented reading of a Sound Effects Directory report (Augoyard, Torgue, 1995) which details its definition in six semantic fields: psychology and physiology of perception, physical and applied acoustics, sociology and everyday culture, musical aesthetics, architecture and urbanism, scriptural and media expressions.

This filmed experience allows to initiate questions about the material conditions of reverberation room (walls volume and materiality) and on the perceptual effects that students can reproduce and stage in the diversity of acoustics in the architectural school rooms that they test by declaiming texts, recording themselves.

4.3 Voice as a universal and durable standard

Acoustician François Canac¹ is the author of an analysis method, which for the first time highlighted the roles of architectural characteristics (bleachers slope, stage, orchestra, parodoi, *pulpitum*, lateral rear walls) contributing to sounds quality perceived in traditional Greco-Roman theaters, from the 5th century BC to the 2nd century BC (Epidaurus, Delphi Pergame, Vaison in Vienna, Orange). He analysed acoustics using two complementary methods: geometric acoustics based on plots and model experiments (wave vessel) which he crossed with an experimental in situ method using voice as main standard for his tests.

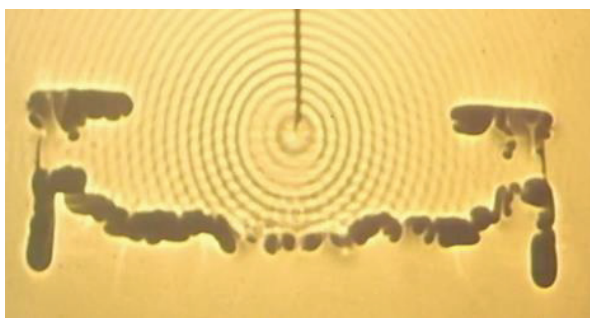


Fig. 4- Wave form 'cuve à onde' antic theater, extrait film Canac, 1966.

Filmed² at the Orange theater, this method show live the role of sources location on stage by appreciating listening

¹ François Canac (1896-1969), the first physicist to analyze the acoustics of traditional Greco-Roman theaters. He published on the subject in 1967, which is still a reference today for transmitting the fundamentals of architectural acoustics.

² Documentary film showing the vocal experiments carried out at the Orange theater by the CNRS team under the direction of F. Canac, director Girard, Service du film de recherche scientifique, CERIMES, 1966, 22'.

only with an audio recording that broadcasts on speakers allows to compare the results from an identical sentence: «the physicists and architects of antiquity had only two means: geometry and ear». This "test sentence" is the main methodological hypothesis of the acoustician who was thus able to validate intelligibility and understanding (logatons) measures, using this high reliability experimental method.



Figure 5. Voice test Orange theatre, Canac, 1966.

Viewing this video reminds students that acoustic science was built on similar sensitive experiments. Between art and sound science, acoustics was formed from natural phenomena observation. From Pythagoras to Galileo, from Mersenne to Descartes, from Newton to Fourier, acoustics history is a slow process built from myths, to finally lead to scientific experimentation, marking the fundamental discoveries of the vibratory phenomenon. In his "acoustics little history" (Liénard, 2001), the French acoustician Pierre Liénard inventories discoveries and academic experiments discovered over the centuries and methodically exposes the main events connected with sound science progresses. The task is not simple because if we attach ourselves to the etymology of the word, *akustike* which means "listening": acoustics is the science that deals not only with the properties of production and propagation of physical phenomenon, but she is also interested in receiving sounds and therefore listening. Consequently, it cannot fail to introduce human (his voice) and complexity of his perceptive activities into its reasoning and models³.

The personal sound experiments described below are extracted from pedagogical activities, acoustics courses or architecture where it was necessary to design with the environments; these two activities were mediated in the form of a conference for the first and a film for the second.

Without ignoring technical advances and new digital tools available to design offices for their rooms modelling, the support of these on site experiments which use voice as a universal standard is essential for architects training,

https://www.canalu.tv/video/cerimes/acoustique_des_theatres_antiques_9038

³ This principle was confirmed during the Renaissance with the first acoustic treatise of A. Kircher, *Phonurgia Nova* (1673), cf. Cécile Regnault communication to the 2nd francophone congress of construction history, 2014. (Paper to be published by Leuven University Press).

allowing a good position as to the positioning of techniques and fundamental acoustic knowledge, articulated to the history of architecture.

4.4 Bursting balloon experiment

Knowing a room reverberation usually done with graphics that only acousticians can decrypt; however, architecture is a collective production. So, how can we share this knowledge if we want her to interact before project, during the diagnostic and design phases developed by the architects?



Figure 6. Reverberation balloon test of, ENSA Lyon, Laboratoire des Ambiances 2016

The hypothesis we formulate is to propose on the one hand methods that associate listening and gesture with the understanding of the phenomena, on the other hand to give audible references to the figures of the acousticians.

Let's take reverb time example, more broadly room impulsive response, mediated by the balloon bursting experiment¹. Well inflated, the balloon blown up with a fine needle emits a pulse in the room of 100 decibels order. This short and intense sound generates a thousand sound reflections on the floor, on the ceiling, on the walls, which depend on architecture (volume, form and materiality) and which gradually go out to reach the room silence at 40 dB(A). Combined with an audible experience directly where we teaches, the reverb time definition logically resulting from this experiment is easily appropriate by students: "time required for the sound to go from 100 to 40 dB(A) is called reverb duration (Tr 60)". We added to this the graphic supports produced by calculation software. The balloon experiment proposes to associate the listening of the room's decreases with their graphical visualizations in real time². Technically easy to implement, this quasi-theatrical performance stems from

¹ This experiment, initiated by acoustician Christian Hugonnet in his lectures for *La Semaine du son*, has been translated into a valuable exploratory method for pedagogy in architecture school (Hugonnet, Regnault, 2016).

² Real time of sound recording and broadcasting has completely changed the relationship between signal analysis and listening to results. These

the pooling of the influence of acoustic distances and the position of the receiver. The audience acclimates collectively to the sound room returns, which they can test in several points.

The experience makes the walls 'talk', expressing the volumes and materials that can possibly be varied if the room allows. Experience "talks the walls", expresses the volumes and materials that can possibly be varied if the room allows. Beyond its demonstrative value, in a conference situation for example, balloon experiment protocols could be standardized as measurements and tests of reference rooms would constitute a common referential to 'make live' for architects.

Realized on existing rooms, to contribute to their rehabilitation, the stakes of this experiment would allow involving the project owner in the desired acoustic changes by also involving the users.

Realized for cognitive purposes³, we imagine tomorrow being able to demonstrate how this controlled manipulation in the ear can become an effective predictability tool for architectural projects.

5. CONCLUSIONS

Transmitting acoustics to architects presupposes active forms of pedagogy that exercise their ears.

From experience to experimentation, the scientific project oriented on the experimental one in forms of search-creation which guarantee an explicit assignment of the sounds.

That the use of sound as a medium which is integrated into the project process is more natural for the professionals of built space. That the architects can experience their ideas in auditoriums in a new manner. These experiments of immersive restitution can contribute to invent holistic, sensitive methods where the analysis, the design and, *in fine*, the production of built space are hybridise *more* than following each other.

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electroacoustic and telematic means are now widely used in educational or artistic applications.

³ Learners go through several cognitive stages: hearing the gaps, analysing the characteristics of a room's reverb, understanding the architectural parameters that can make them vary, that we have been able to identify but that the mechanisms should be analysed more closely.

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