

Architecture and sounds the interdisciplinary research on the use of audio signals in the cognition and design of architectural space

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Abstract: In the contemporary world of image, the basic attribute of architecture is its visuality. Architectural spaces are designed primarily to be viewed by the public or the "eyes" of cameras. The design for the sense of sight only impoverishes the quality of human contact with architecture. The art of shaping space should involve all perception channels. One of the most important senses, allowing to feel the created space, to get to know it and live in it, is hearing. The sonic image of architectural space not only accompanies the visual image, but also significantly defines the quality of existential and aesthetic experiences. The architect's task should be to skilfully use acoustic signals as an integral part of the design process. This belief has inspired a multidisciplinary project entitled: "Sounds of architecture", devoted to the study of the phenomenon of sound and its significance in the perception and use of the architectural environment by people. This project was carried out under the guidance of the author in 2014-2015 with the involvement of representatives of various disciplines of science and art. The result of interdisciplinary research was the monograph "Sounds of Architecture", published in 2016.

Keywords: multi-sensory design, extra-visual perception, sound space, audiosphere

1. Introduction

In the perception of postmodern man, the outside world is the reality of the image. The human eye – an efficient, vigilant mechanism, reinforced with many objects ("extensions" of the natural sense), perfectly perceives, registers, researches, frames, freely zooms in or out images. Contrary to the primary laws of optics, today a man is able to "stop" transient visual phenomena and operate them perfectly, making images invaluable tools of social impact, non-verbal communication and manipulation [16].

In the postmodern world, the visuality is a fundamental attribute of architecture. The advantage of sight as a tool for cognition of architectural space manifests itself at all "levels" of perception processes: from unconscious perception of the background in search and identification of essential elements ("level" of impressions), through momentary focus on specific architectural images ("level" of observations), to fully conscious inspection of selected objects, allowing for their multi-criteria analysis and evaluation on the basis of obtained visual information ("level" of mental cognition).

Orthodox ocularcentrism, manifesting itself in the attitudes of the contemporary architects, but also in the expectations of their clients, seriously impoverishes the potential of architecture – multi-modal art, capable of providing usefulness and arousing admiration through various sensory channels [16], [17]. The progressive deprivation of other senses of

the human sensory system leaves its mark on both the existential and aesthetic aspects of cognitive experience. Architecture – the art of shaping space should involve all perception channels (and thus, apart from the sense of sight, also the sense of touch, smell, taste and hearing), thus creating a complete, truly valuable image of the built space [12].

The above considerations inspired the author to search for "lost" languages of contemporary architecture. One of them remains the language of sounds - inherent, though definitely underestimated characteristics of the built environment. The belief that there is a multiple value in audio signals, still rooted in ancient architectural treatises and echoing back in successive epochs of the construction art, seems to require a special reminiscence. Especially today – in the era of visual architecture, oriented primarily on the use of visual information. These reflections became the basis for a multidisciplinary project entitled "Sounds of architecture", devoted to the study of the phenomenon of sound and its significance in the perception and use in the architectural space. This project was carried out by the author in 2014-2015 with the participation of the representatives of various disciplines of science and art.

The topic of sound in the literature on architecture is present mainly in specialist studies on urban acoustics and building acoustics (within the domain of engineering knowledge) [4], [15], [19], [23], [25]. The available sources concern mainly the issues of sound propagation as well as generating and correcting acoustic phenomena in urban and architectural space and interior design. Apart from these works, which continue the physical approach (the oldest scientific approach to acoustics), within the blurred boundaries of architecture, a trend of research on human sound environment is currently being developed, seeking scientific support within such disciplines as: architecture psychology, humanistic geography, sociology and cultural studies [16], [17], [26]. These sciences bring to architecture the notion of sound as a phenomenon, embedded not only in the biological and intellectual abilities of man, but also in his psyche, spirituality and cultural codes of the environment. One of the branches of this domain is interdisciplinary research in the field of shaping, protection and revitalisation of broadly understood landscape (including sound landscape), within the formula of sustainable urban development. The research is complemented by bio-architectural analyses of universal design, presenting the compensatory, but also complementary role of sounds as a language for reading the spatial environment.

The idea behind the "Sounds of Architecture" project was to take an interdisciplinary and possibly broad approach to the subject, presenting the phenomenon of sound from many different research perspectives. The aim of the scientific project was to present the potential of audio signals as an integral component of architecture, including active design material, but also as the way to a fuller experience of architectural space by man.

Representatives of various disciplines and areas of science, culture and art were invited to participate in the project, including urban planners, landscape architects, architects, interior designers, engineers, acoustics, anthropologists, culture experts, specialists in disability issues, museum workers, musicologists.

The starting point for the scientific discourse were the following suggestions:

1. Undesirable sounds. Discomfort and risks associated with acoustic phenomena.
2. Useful sounds. The use of sounds for spatial orientation and mobility.
3. Desired sounds. Sound as a generator of positive experiences. Emotional dimension of sounds. Sound aesthetics.
4. The sonosphere. Acoustic landscapes of places. The audiosphere. Phonetic identity of space. Protection of the audio landscape.
5. Acoustic ecology. Acoustic sterility.
6. Sounds of buildings, sounds in buildings.

7. Music and architecture. Houses for music. Analogy, complementarity, synergy of aesthetic experiences.
8. The phonosphere. Acoustic presence of a man in architecture. Spoken word as a tool for shaping the concept of architectural space.

The thesis for targeted, multi-author analyses became the conviction that the broadly understood "sounds of architecture" constitute a significant "layer" of architectural space, shaping the perception of the rich world of architecture.

2. The course, themes and results of the research

The research team consisted of 14 researchers representing the following universities and institutions: Faculty of Architecture and Faculty of Civil Engineering and Environmental Sciences of the Białystok University of Technology, Faculty of Civil Engineering and Architecture of the Lublin University of Technology, Faculty of Architecture and Faculty of Electronics of the Wrocław University of Technology, Faculty of Civil Engineering of the Częstochowa University of Technology, Faculty of Architecture and Faculty of Civil Engineering of the Kraków University of Technology, the National Museum in Kraków, Institute of Cultural Studies of the University of Wrocław, Maria Curie-Skłodowska University in Lublin. Specialist education and scientific experience of the authors made it possible to place selected topics of discussion in the context of a number of disciplines, including: technical-engineering sciences (architecture and urban planning, automatics, electronics and electrotechnics, civil engineering and transport), science and natural sciences (life sciences, Earth and environmental sciences), humanities (cultural and religious sciences, art sciences, history of art), social sciences (social communication sciences, socio-economic geography and spatial management, sociological sciences). Extensive and diverse professional background of the authors was an important asset to conduct research at the interfaces of disciplines, in unclear and not necessarily recognised areas.

The result of the work of the research team was a scientific monograph "The Sounds of Architecture" [7], containing a number of proprietary papers, presented in 5 thematic areas. Logically, the presentation of the research results is a transition from measurable criteria (physics and mathematical models of sound) to hardly measurable values of the acoustics of the architectural environment. In addition, a discussion on subjective issues of sound aesthetics and symbolism attributed to certain sounds was also held.

The scope and results of the research undertaken in particular 5 areas are discussed in the following subchapters of this text.

2.1. Sound issues in building physics

The first element of the research was to define the physical nature of sound and basic physical concepts essential for the purpose of scientific understanding of the phenomenon of the acoustic wave. The currently available methods of modelling acoustic phenomena as well as the most important properties and physical parameters of room acoustics were analysed. The elaboration of the discussed topic were the analyses of insulation of acoustic partitions and basic determinants of sound penetration through various building partitions. On the selected example of a partition, the values used for the assessment of acoustic insulation of building partitions were analysed. Attention was drawn to the current problem of inaccuracy of commercial information related to these parameters.

2.2. Architectural acoustics

The next step was to analyse the topics of the so-called architectural acoustics – a unique field of interdisciplinary cooperation between designers from different disciplines involved in the construction process. There were discussed the principles of this sometimes difficult inter-branch cooperation, subjected to achieve the desired results in three basic areas of acoustic design of buildings, including: noise protection, noise emission and interior acoustics. An attempt was made to identify the key problems of the design process and to indicate the rules for the optimisation of dialogue between acousticians and main designers, as well as between acousticians and other professionals [9].

A part of the research in this area was the analysis of architectural methods propagated from the 11th to the 16th century A.D., which involved embedding pots into the walls of pendentives or vaults of many representative buildings (including sacral buildings). Some sources indicate that they served as loudspeakers to improve the acoustics of buildings. This hypothesis is supported by the ancient treatise of Vitruvius, which provides practical advice on the use of copper, brown or clay pots in the construction of theatres [24]. At the same time, the literature on the subject also includes sources undermining the "acoustic" roots of this custom. Reasons for this are found, for example, in the engineering of construction (reduction of the weight of walls and vaults) or construction technology (mounting of scaffolding rods). Some of them give also liturgical or mystical explanations.

Two different architectural approaches representing the same idea of intentional use of sound as an important and noticeable "component" of architecture have been analysed. The first of the observed phenomena were architectural buildings with interiors designed in such a way as to be a kind of natural resonators. As it was proved, the desired acoustic effects in these interiors can be enhanced by such measures and components as: natural material, appropriately shaped surface tectonics, accurate geometry of the projection of the hollow space and the shape of the vault. The second of the analysed approaches exemplified architectural structures with artificial sonic environment. In the research, special attention was paid to the so-called multimedia projects, including interactive installations and sound sculptures, in which a key role is played by the human body's motility [3].

The last element of this area of research were analyses devoted to the issue of complementarity and proper correlation in architectural design of acoustic issues and visual aspects. As it has been demonstrated, the visible image of often extremely complicated acoustic solutions becomes particularly important in spaces with the so-called qualified acoustics, including prestigious concert halls, theatres, auditorium halls, etc. An inseparable element of the interior design composition are specialist spatial structures, ensuring appropriate acoustics, and at the same time significantly determining the aesthetic reception of interiors [6], [10].

2.3. Sound as a carrier of information in the architectural space

One of the parts of the extensive field of multisensory design was the research on contemporary use of sound in the Polish museum institutions. As it was observed, appropriate coding and reception of customised (in terms of language, narration, content, route variants, volume, etc.) announcements to visitors is a new social phenomenon and the unique fashion for interactivity (multimediality), increasing the value of museum exhibitions. The conducted research has also demonstrated the importance of such auxiliary solutions as universal and discreet tools to help the blind and visually impaired visitors, for

whom an alternative soundtrack is often the only way to discover the collections of a museum [21].

While continuing research on the informational value of sounds for mobility and the use of architectural space by visually impaired audience, it was concluded that an accurate analysis of the phonic landscape - acoustic signals characteristic of certain places – can become an invaluable way for blind people to create mental images of urban space [11], [22]. This thesis was supported by an innovative method of orientation in the city area using the sounds of the environment, developed by an interdisciplinary team of Polish scientists in 2010 [20].

2.4. Acoustic identity of architectural space

The research carried out in this area opened the way to analysis of the problems of progressive loss of phonic identity in the areas of human residence. As it was noted, cities in different parts of the world are becoming more and more acoustically similar to each other, losing their unique acoustic character and thus deconstructing irrevocably coherent, polymodal image of the so-called "spirit of the place". Meanwhile, the unique repertoire of sounds associated with indigenous, local culture and contemporary social activity is an element that leaves unusual, vivid images in human memory, imprinting their aesthetic stigma to a degree not lesser than the colourful visual images of the surroundings. Thus, it has been proven that city design is a process in which it is necessary to consider the sounds produced by each component of the spatial structure. It has been suggested that one of the elements of multi-criteria analyses of urban space should be the preparation of maps that would valorise sound space on the basis of the perceptions of its inhabitants.

The subject of acoustic and architectural identity of cities was also pursued in the aspect of urban spaces that are dedicated to music. The analyses were carried out on the basis of unique realisations of Scandinavian concert halls constructed during the last years, which became recognisable elements (or even symbols) of the urban structure and the building blocks of a new identity of cities.

The subject of the team's research were also questions related to the so-called sound landscape of places and spaces. These analyses were conducted on the example of the audiosphere of residential complexes, realised in the 1970s and 1980s in Wrocław [13], [14]. Attention was drawn to the characteristic acoustic identity of residential spaces, created both by specific urban and architectural solutions, as well as by the habits of people. When analysing the sound environment of "blocks of flats", a characteristic difficulty in separating public and private spaces was observed (private sounds – sounds of home easily penetrate into the common space). The spectrum of research also covered the topics of subjective reception of housing estate sounds, analysed on the basis of interviews (statements of residents) obtained during field research.

An important element of this part of the research were analyses related to the subject of creative interference in the sound landscape of the city (acoustic revitalisation of the landscape) in order to restore authenticity, appropriate values or purity of the sound landscape. Attention was drawn to the growing interest of the public in the subject of sound identity, manifested for example by the creation of special "sound walks", "sound maps", "sound postcards". They are part of the promotional activities of many cities in Europe and all over the world, which use the so-called soundmarks (characteristic sounds which are the symbols of places) and sound landscapes. The research also identified the problem of increasing noise and pollution of the human sound environment associated with the rapid development of the automotive industry. The intention of the research was to demonstrate the need to take into account the potential of sounds in design and implementation

processes aimed at revitalisation of urban spaces. Referring to R. M. Schafer's research [18], it was concluded that in practice, these activities should include maintenance, "repair" and proper design of sounds in given areas [1], [2].

Another important aspect of the architectural and phonic identity tandem was addressed in another research thread, focused on the analysis of rural areas in the Polish-Belarusian borderlands. As it was observed, the Orthodox communities living in these areas have preserved to this day the attributes of traditional cultures, in which the basic category of consciousness is determined by religion, combined with pagan demonology and animistic beliefs. Celebrated holidays, both those from the Julian calendar and ordinary family celebrations, were inseparably connected with traditional music and singing. They gave the proper setting to all important events and ceremonies, determined their course and character. As it was shown, these songs, resounding in human homes, their neighbourhoods and also in the countryside, should be treated as indispensable attributes shaping the identity of the spiritual culture of rural ethnic communities.

2.5. Sound as a carrier of emotions in architectural space

The final part of the research was devoted to the use of sound as a carrier of emotions in architectural space. The scientific discourse began with analyses of the issue of conscious use of sound in social rehabilitation of blind people. As was attempted to prove, conscious (properly supported) analysis of phonic signals can become a path to emotional, including aesthetic, experience of architectural space. This theory is supported by practice based on e.g. learning to shape spatial images through the language of music and sounds [5], [8]. Although they are used by some Polish therapists (and art-therapists), they are not always treated as equally important elements of multi-aspect typhlorehabilitation. As it was determined, issues related to the creation of emotional images of space do not currently have a solid scientific basis. Therefore, the use of rehabilitation possibilities of sound in this aspect requires further research, systematising this domain in theory and allowing it to be used in practice.

The closing element of the discourse was a scientific reflection on the concept of sacrum – the experience of the sacred, integrally connected with the reception of acoustic phenomena. The silence of sacral interiors and places of remembrance, where a conscious architectural procedure of cutting off from the outer audiosphere makes it easier for the recipients to achieve a state of contemplation and concentration, was "listened to" in a special way. Attention was drawn to the human need to commune with silence and the importance of silence in the contemporary world. The second aspect of the research – shaping the sense of sacrum through appropriate sounds - both those coming from nature and those being the product of conscious human activity – was also analysed. Two elements, which are the components of sacrum, elation (fascino) and the experience of horror (tremendum), were defined and explained.

3. Synthesis of research and further research perspectives

The interdisciplinary research carried out as part of the "Sounds of Architecture" project has revealed a number of multi-criteria architectural problems that can be solved by implementing the expertise in the domain of acoustics. As it was demonstrated, the effect of multidisciplinary cooperation can lead to a number of values experienced by users of architectural space at different spatial scales (large urban space, medium space of structures and buildings, small space of architectural interiors).

The results of a comprehensive research show, first and foremost, the following advantages:

- comfort of use and functionality of space (including collision-free use of complex spaces, functioning of special buildings dedicated to sound reception),
- safety and sense of security in using space,
- cognitive values (related to direct or indirect cognition of new places and facilities),
- informational values (including identification of places and objects, individual communication and social communication systems in the architectural space),
- cultural values (related to the identity and recognition of places)
- economic values (related to individual and mass tourism to places and buildings)
- creation of desirable social behaviours (usable culture),
- health and rehabilitation (including typhlorehabilitation),
- recreation (psychophysical regeneration in the sound landscape),
- aesthetics of sound,
- symbolism of sounds.

These properties seem to undoubtedly indicate the need for implementation and constant use of acoustic knowledge in the broadly understood domain of architecture. One should take into account its practical dimension (related to design, realisation, making available buildings and space, as well as space management), the creation of modern legislation and the issue of modern and wise education of architects – ensuring an appropriate level of practical training.

The discourse has revealed many complex issues within the designated research area. Individual research, which was an attempt to delve into selected panels and topics, is only a part of the research field, in which acoustics is intertwined with architectural knowledge and practice. In order to better identify and use the potential of sound in architectural and urban design, further discussion is needed with the aim of:

- extending and substantial complementing the issues indicated by the authors,
- supplementing the problem areas with threads that could not be developed by the appointed research team,
- successive identification and scientific development of new fields of acoustics that enter into the spectrum of architecture.

Among the topics that the author recognises as the coordinator of the project and the creator of the debate framework, there are in particular such issues as:

- Analogy of architectural art and music – this matter, although existing in the literature, did not find its place in the debate.
- Acoustic information and warning systems in the urban and architectural scale – this topic is discussed in the literature on safety in public space and the situation of the people with visual impairment and/or the elderly. In the described paper this topic is only mentioned, and it certainly requires particular attention and further elaboration.
- New methods and techniques of transmitting of acoustic information in tourism and city promotion – this topic, referring to new, universal tools of social communication (including tools linked to personal devices of visitors), is not included in the work. Due to the rapid technological development and evolving social expectations (including in particular the recognition of the needs of the people with disabilities), this field requires constant monitoring and updating of knowledge, but also its appropriate use in the field of architecture.

- The problems of the deaf and hard-of-hearing in the architectural space – despite invitations, the experts who could provide specialist knowledge in this domain didn't join our project. This area is currently not sufficiently recognised and popularised in the literature on architecture.

The outlined aspects, as well as the topics and hypotheses identified by the research team may serve as a starting point and inspiration for further research in the area of architecture, aiming at recognising the role of sound and its effective use in the design and reception of architectural space. Continuation of open discussion and simultaneous exploration of new research threads require the cooperation of a wide range of specialists representing various scientific disciplines, including branches of science defining scientific bridges between architecture and acoustics.

4. Summary

This paper is an attempt to draw attention to the enormous, but at the same time definitely underestimated potential of sounds in architectural experience. This issue still remains on the margin of education in the area of architecture and conducted scientific research. However, it requires a special mention, observation and adequate scientific basis. In the era of the primacy of the human eye, supported by the rapid development of visual technologies, we too easily limit the narrative potential of architecture only to the language of sight. Meanwhile, as the above publication has attempted to prove, auditory impressions, perceptions and experiences can have a huge role in creating and enriching the relations between a man and architectural space. Yet, this requires architects to master the "language" of acoustics, which enables them to control and use (eliminate, generate, correct, shape, nurture, etc.) specific phonic signals of the spatial environment.

A proper grasp of the problem of sounds in the design process may become a way to create architecture that better meets existential needs (readability, comfort, safety, recognition), but also aesthetic needs of a man (surprise, curiosity, beauty). The sketched depth and variety of auditory experiences while using architectural space seems to be sufficient to understand acoustics not only as a subsidiary branch, but even as a complementary part of architecture.

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