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Shape, Function and Sound – The biological limits of Biomimicry and its analogies

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Abstract: Biomimicry is a useful methodology for developing efficient solutions to human challenges in various areas of knowledge, including architecture and design, based on observations of nature and for this the literature already address different methods such as analogies. Thus, this article starts from the perception that Biomimicry and its analogies are inspired by the visible dimension of nature, as shapes and functions of certain natural element. With this, there is the possibility of discussing Biomimicry from the audible point of view of nature, rescuing the soundscape as an inspiring natural element and increasing the scope of analogies discussed in literature.

Keywords: Biomimicry - Sounds - Soundscape - Analogies - Architectural design - Bio-inspired design

[Resúmenes en castellano y en portugués en las páginas 131-132]

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Introduction

The constant evolution of nature and the advancement of digital technologies in the field of architecture and design, in recent decades, has driven the development and transformation of the design process. In this context, Biomimicry through analogies that support the strategy of emulation, allows the transfer of ideas and principles developed by nature for the design of sustainable and innovative proposals.

Although the term 'Biomimicry' is historically recent, its idea dates to Greek mythology and the myth of Deadalus and Icarus. Later, in the Renaissance period, the quest to create tools that would enable human flight caused Leonardo Da Vinci to look to nature for inspiration in the movements of bird and bat wings to develop sketches of bionic mechanisms through his study entitled *Sul volo degli uccelli* (Codex on the Flight of Birds) *(See Figure 1)*. Though unsuccessful for that time, his studies were considered starting points for futures researchers, and he became one of the first people to study forms and functions present in nature (Cruz, 2012, p. 30).

Figure 1. Leonardo Da Vinci' sketches and Bionic study developed in his work Sul volo degli uccelli Source: Cruz, 2012, p. 29).

More recently, the term Biomimicry appeared in 1982 and was widely disseminated from 1997 with the book 'Biomimicry: Innovation Inspired by Nature' by Janine Benyus (Benyus, 2006). Thus, Biomimicry was consolidated as a discipline that studies and imitates forms, processes and behaviors of nature in order to solve human problems in several fields of knowledge, including architecture and design, under the premises of resource efficiency and sustainability.

That is, Biomimicry seeks inspiration in nature, taking advantage of shapes and characteristics that it has already developed the best for ages, to develop functional and sustainable solutions to human challenges. However, it is noticeable that much of the research involving this theme addresses 3 types of analogies (Soares & Arruda, 2017, pp. 39-40). The morphological analogy studies morphological shapes and patterns found in nature, the functional analogy seeks to emulate functions performed by natural elements, and the

morpho-functional analogy combines the previous two. A fourth, called symbolic analogy (Soares & Arruda, 2018, p. 77) has been debated and addresses the dimension of meaning, and its emulation of nature's elements is more abstract and without as much fidelity to shapes and functions; it may reflect a personal interpretation of the natural reference.

With this, based on concepts and design strategies already addressed in previous investigations, we realize the possibility of developing the theme of Biomimicry allied to design processes. As identified earlier, it is observed that the natural inspirations are often restricted to the visible dimension of what is physically observed from the elements of nature.

Working on the sound dimension of architectural spaces is less intuitive and more complex as it is not enough to observe physical parts of buildings and their visible relationships. Hence, we need to explore the sound dimension to allow the transfer of natural principles of the soundscape and incorporate them into the process of project in architecture and design.

So, it starts from the premise that the sounds of nature compose a universe as rich as what can be observed from it, being a possibility of study for integration with pre-defined concepts of biomimicry. Thus, there is an opportunity to establish a design method based on sound information from the environment.

Thus, based on the analogies already discussed in the literature, it is verified that none of them deals with the sound issue of the surrounding environment, natural or artificial. This way, Biomimicry when proposing the discussion of Sound Analogy would investigate the sounds emitted by the environment. These sounds would be translated through digital systems into geometrical forms or patterns, which could be used for the development of design or architectural objects.

In order to capture nature sounds, it is important to define the types of sounds relevant to the research. These may refer to Biophony and Geophony (sounds from nature), and Anthropophony and Technophony (sounds that are not natural but are sometimes present and audible in the natural soundscape, and impact the environment surrounding nature) (Krause, 2002, pp. 2-3; Mullet *et al.* 2017, p. 326).

Thus, the paper proposes to approach the panorama of biomimicry analogies already discussed in the literature, to insert the discussion about the possibility of the relationship between Biomimicry and environmental sounds, widening the perspective of the biomimicry project process.

Biomimicry combined to Soundscape

One of the potentialities of Biomimicry as a science is the possibility of transposing natural constructive means to human fields of action, propagating this as a method of research project in architecture, design, and engineering, and seeking to achieve an idea of self-sufficiency.

Thus, Biomimicry presents itself as a promising area of study, in constant development since nature is a universe of research with immeasurable scale. Biomimicry applied to

architecture makes it possible to conceive ideas through natural morphological patterns, in addition to developing creativity by highlighting a new context for the development of logically based ideas.

Analogies, on the other hand, are effective methods of learning based on previous concepts and ideas for formulating new knowledge. In Biomimicry, they work as a means of interpreting and transferring knowledge from the natural / biological reference to what is being developed.

Furthermore, analogies allow solving problems based on the stimulation of logical reasoning as a means of decision making in different fields of activity, creation, and perception. As a result of the development of this analogical method, it is possible to develop a series of solutions for different types of challenges addressed by science, and in this sense Biomimicry works as a cognitive process of the interpretation of the inspiring natural element for the development of artificial systems (Clementino *et al.*, Soares & Arruda 2021/2022, p. 176) *(See Figure 2)*.

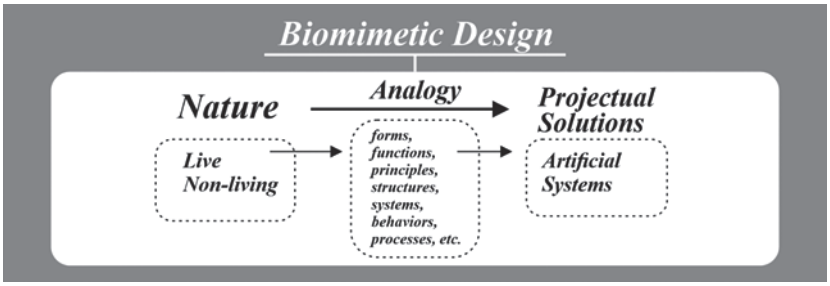

Figure 2. Diagram of the biomimicry design process through analogies (Source: Clementino, Soares & Arruda 2021/2022, p. 177).

Despite the search for an efficient method to work with biomimicry, this is still an empirical science and there is still no concrete methodology, in view of the complexity of translating biological systems to the technological field. The development of solutions through biomimicry goes much further than inspiration or copying elements of nature (Santos, 2010 as cited in Araújo, 2015, p. 34).

> No general approach has been developed for biomimetics, although a number of people are currently developing methods for searching biological literature for functional analogies to implement. We think that this is only part of the required framework. Although it is well known that design and engineering

> are rendered much easier with use of theory, in biomimetics, every time we need to design a new technical system we have to start afresh, trying and testing various biological systems as potential prototypes and striving to make some adapted engineered version of the biomimetic device which we are trying to create. Additionally, the transfer of a concept or mechanism from living to nonliving systems is not trivial. A simple and direct replica of the biological prototype is rarely successful, even if it is possible with current technology. Some form or procedure of interpretation or translation from biology to technology is required (Vincent *et al*. 2006, p. 474).

Therefore, as the current concepts of Biomimicry are not yet related to the study of sounds coming from the natural environment (or any other kind of sound), it is important to understand what Soundscape is, as well as what composes it. According to Liu *et al.* (2007, as cited in Pijanowski *et al*. 2011, p. 203), although sound is part of nature as a fundamental property and can be drastically altered due to human activities, this is still not such an explored measure from the point of view of a system that relates inhabitant-environment. Thus, soundscape can be described as the relationship between the landscape and the composition of its sounds (Pijanowski *et al*. 2011, p. 203).
In 1977, Schafer (1993, p. 205) stated that sounds are ecological properties of landscapes and introduced the concept of Ecological Acoustics. In 1987, Krause (1987, p. 17) sought to describe the arrangements of natural, biological, and other environmental sounds and how these can affect the ecosystem as a whole; later in 2002 he introduced the important concepts of Biophony, Geophony and Anthropophony *(See Figure 3)*.
Biophony is characterised by the sounds emitted by any organism in a given habitat. Geophony is understood by non-biological sounds emitted by the environment, such as thunder, sea waves and winds. Anthropophony, on the other hand, consists of the sounds generated by human beings, such as in a theatre or during a concert (Krause, 2002, pp. 2-3).

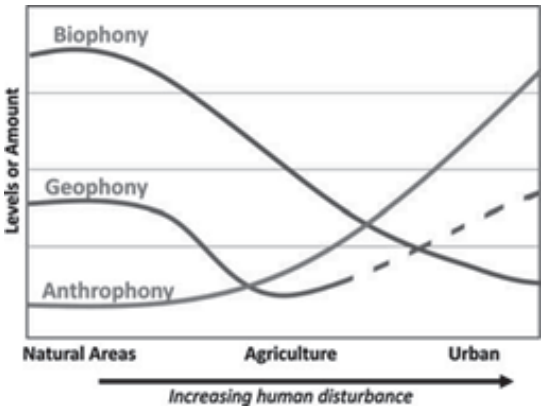

Figure 3. Soundscape variation model (Note: Conceptual illustration of the variation of soundscape elements depending on the intensity of human disturbance caused in the environment. The dashed line depicts a possible pattern. Source: Pijanowski *et al.* 2011, p. 10).

Another sound relevant to the study of soundscape is Technophony, or the sound produced by human-built machines, which has become common in natural landscapes (Mullet *et al*. 2017, p. 326).
Another concept, Soundscape Ecology (Pijanowski *et al*. 2011, p. 204) has nothing to do with a field of ecology and is described as all the previously mentioned sounds emitted in a given environment to produce unique acoustic patterns across spatial and temporal scales. Differently from this concept, Bioacoustics (Fletcher, 2007, p. 785) is the study of animal communication and its behavioural relationships, addresses the production of sound and theory of animal life.
Currently, there are already researchers engaged in the study of Bioacoustics, Soundscape, and Soundscape Ecology, who have recordings of many different kinds of elements and environments. Bernie Krause has recorded around 5,000 hours of sounds of almost 15,000 species from diverse ecosystems, ranging from Kilimanjaro[1] to the Amazon[2]. With that, he created the Wild Sanctuary Foundation. In Brazil, biologists Marina Duarte (PUC-Minas[3]) and Renata Sousa-Lima (UFRN[4]) began monitoring Brazilian ecosystems and captured about 800 hours of recording in each of them, from which they established metrics and analysis guidelines (Zorzetto, 2019).
Given the vast perspective of research of the soundscape, it is proposed to combine it with Biomimicry to theoretically formulate information transfer strategies and develop practical means of transposing the sounds of nature, or other non-natural environments, to explore the conception of projects in architecture and design.

The Analogies

The field of analogies, already much discussed, dates back to Classical Antiquity when the Greek philosophers Aristotle and Plato discussed it as an abstraction shared between analogous objects, i.e., that had some characteristic in common such as a pattern, regularity, idea, attribute or function. However, analogy as a method has become a promising technique to stimulate creativity through the repeated use of associations and has been adopted by researchers since the publication of the work Synectics, by William Gordon in 1963, in which he approaches 4 types of analogies (Soares & Arruda, 2018, p. 76).
In addition to this, Soares (2016, p. 31) states:

> All these analogies somehow strive to translate the natural world and contribute to the decoding of geometries, functions, and in the search, among other aspects, for a better use of energy and material, thus preserving the principles of Biomimicry [translated by the authors].

Next Soares & Arruda (2018, p. 76) comment on the analogies defined by Gordon (1963)

- Direct Analogy: Refers to the comparison of knowledge, facts, organisms, and objects that have some level of similarity.

• Personal Analogy: Consists in an immersive embodiment in the problem, allowing an internal vision about thoughts, feelings, and ways of acting for each context. In addition, it raises the question: If I were a... how would I feel?
• Symbolic Analogy: Besides using objective and impersonal images to describe a problem through a poetic response, it is possible to create a series of associations.
• Fantastic Analogy: Allows the development of imaginary solutions encompassing the field of fantasy while leaving aside logical and rational thinking.
Regarding Biomimicry, analogies enable the emulation of natural characteristics found in inspirations and references sought exclusively within the field of nature for the resolution of challenges in various fields of knowledge. Thus, Steadman (1988), Bonsiepe (1992), Arruda (2002), Soares (2016), Clementino *et al.* (2021/2022) discuss other types of analogies that allow direct integration with the natural environment.

Steadman (1988):
• Organic Analogy: Seeks balance between human organisms, works of art, and mechanical systems (Steadman, 1988 as cited in Soares, T., & Arruda, A., 2018, p. 15).
• Classificatory Analogy: Seeks methods determined by botany and zoology for application in architecture and design (Steadman, 1988 as cited in Soares, T., & Arruda, A., 2018, p.15).
• Anatomical Analogy: A metaphorical comparison is made between the shape of the building and the skeleton of animals from the supporting structures such as pillars, beams, and vaults (Steadman, 1988 as cited in Visozo, 2015, p. 35).
• Darwinian Analogy: Compared to Charles Darwin's natural evolution theory, it seeks to explain that objects and constructions are the result of works of trial and error in which several varied experiments are promoted in which it is possible to make the detection and removal of errors (Steadman, 1988 as cited in Visozo, 2015, p. 35).
• Ecological Analogy: It is based on the principle that animals and artifacts owe their shape to their function and this function is related to the environment in which it is found (Steadman, 1988 as cited in Visozo, 2015, p. 35).

Bonsiepe (1982):
• Morphological Analogy: Experimental search for references developed from the interpretation of formal and structural attributes to transform into a project (Bonsiepe, 1992, p. 50). As an example, the plants of the specie *Arctium lappa*[5] have elongated structures with microscopic hooks on their extremities and served as inspiration for the development of Velcro.

Arruda (2002)
• Sensory Analogy: Seeks to develop strategies to control and transmit information from organisms and transpose it into electronic and mechanical systems (Arruda, 2002 as cited in Soares, T., & Arruda, A., 2018, p. 15).

Soares (2016) based on Liua & Jiang (2011)

• Functional Analogy: Considers functional attributes and specific qualities based on the study of the physical and mechanical systems of the biological material (Soares, 2016, p. 34). Thus, it is possible to mention the micro-rough surface of the Lotus flower petal, that confers the hydrophobicity and self-cleaning properties to the structure.

Soares (2016):

• Symbolic Analogy (semantic): It consists of an abstract representation resulting from the researcher's personal interpretation of something that is intended to replicate from nature and does not correspond to shapes or functions of biological organisms (Soares, 2016, p. 38). The works of the Catalan architect Antoni Gaudí are representative of this type of analogy by the use of parabolic torsions on the façades, use of curves and counter-curves, representation of elements of nature as details of his works. Examples include the Sagrada Familia Cathedral, Parque Güell, Casa Milá and Casa Batlló (Clementino *et al*., 2021/2022, p. 182 and 183) *(See Figure 4)*.

Figure 4. Gaudí's works in Barcelona: Sagrada Família Cathedral (left); Casa Batlló (centre); and Casa Milá, also known as La Pedrera (right) (Note: The façade of the cathedral has curved sculptures, a pinnacle with a cypress and a representation of a dove (left); the façade of Casa Batlló has an undulating surface covered with mosaic, balconies with a metallic structure similar to bones, and the coloured roof is resembles the skin of a reptile (centre); Casa Milá has a façade with curved lines, the undulations of the design allude to the sea, and the balconies have a vegetal shape resembling vines. Source: author's file).

Clementino et al. (2021/2022):
• Morphological Structural Analogy: It seeks inspiration in the structural and sustaining elements of natural elements, as well as parts, components, or systems inherent to this bio-inspiring element. Thus, this type of analogy makes the transposition of studied natural structural forms and the emulated object. As an example, there is the ribbed structure of the *Victoria amazonica*[6] that served as inspiration for the Crystal Palace (Joseph Paxton, London, 1951), and the human femur that inspired the development of the Eiffel Tower (Gustave Eiffel, Paris, 1889) (Clementino *et al.*, 2021/2022, p. 178).
• Movement Analogy: It consists of emulating the movement of certain natural elements, or the movement of parts of a natural system (Clementino *et al.*, 2021/2022, p. 180). Thus, the crawling and articulated movement of a snake, or the shaking of its tail, or even the movement of the tentacles of an octopus can serve as inspiration for proposals of bio-inspired products.
• Behavioral Analogy: It refers to the interpretation of more specific characteristics of a given natural element that goes back to its evolutionary history and thus made this element more adapted to the environment and ensuring its perpetuation (Clementino *et al.*, 2021/2022, p. 180). It is possible to mention the behaviour of releasing ink by the squid when threatened and the colour change of the chameleon.

Methodology and Expected Results

The methodological path of the paper presents a systematic mapping of concepts that relate Biomimicry and Soundscape. Subsequently, strategic readings were carried out in order to outline the panorama of analogies used in the biomimicry design process discussed in the literature.
Then, it was sought to explore Biomimicry as a design method, the scientific overview and concepts of soundscape, the historical overview of analogies as a design method, and the association of architecture and sounds through the rescue of the historicity of architectural treatises.
In this way, by showing Biomimicry as a science under development from the methodological point of view and by the approximation with several fields of knowledge, the possibility of expanding the theoretical field of analogies with the insertion and discussion of Sound Analogy is evidenced.

Discussion

From the architectural point of view, it is important to make a philosophical reflection on the sound approach in architecture, and the verification of how the literature addresses

the transfer of sound characteristics and patterns to the formal dimension. Thus, it is possible to mention the architectural treatises of Vitruvius (1st century BC), Alberti (15th century), Palladio (16th century), Blondel (17th century) and Guarini (17th century) (Del Comune,2010, p. 39) that, in general, relate architecture and sounds through: (i) association of music with mathematics, (ii) analogy between the human body and harmony, (iii) harmonic, arithmetic, and geometric proportions, (iv) harmonic reasons.

Martins & Pivetta (2019, pp. 47 and 48) discuss that one of the ways to associate music [sounds] and architecture is through the translation of the elements that constitute music, such as rhythm, melody, harmony, and timbre. Whereas rhythm can be represented by the regular repetition of an element, melody is associated with the general organisation of the form, harmony is represented by the scale and height of the forms, and timbre can be associated with the colour of the sound and would be represented by the textures of the materials.

Thus, the translation of sounds into architectural object can be developed based on different tactics and theories already developed, but there is a need to transpose the relationship between music and architecture that has been debated for centuries to the context of natural sounds.

Unlike forms and functions that are more easily perceived, the sound dimension needs to be analyzed and interpreted differently for subsequent transfer of information and emulation *(See Figure 5)*.

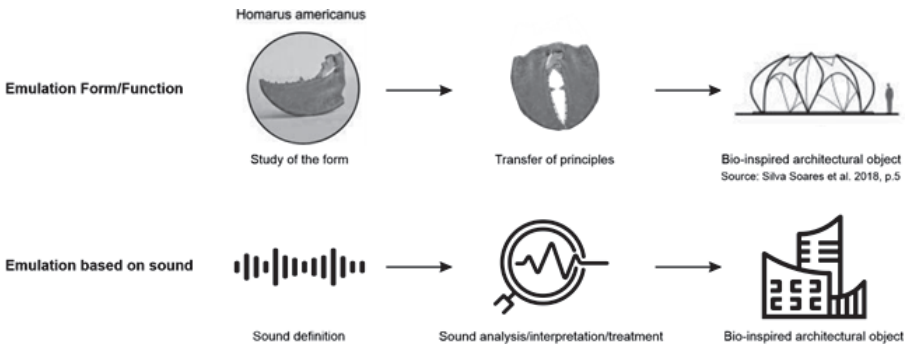

Figure 5. Comparison of emulation processes. (Note: Prepared by the author, 2023, based on Silva Soares *et al.,* 2018, p. 5).

Through technological tools, such as music production and soundscape analysis software, it is possible to visualise sounds graphically through sound waves and graphs known as spectrograms *(See Figure 6)*. These are graphs of energy per frequency per time, in which they outline sound wave data converted into amplitude levels per frequency (Pijanowski *et al*. 2011, p. 206). In this graph it is possible to check these 3 dimensions, time on the x-axis, frequency on the y-axis and energy, or amplitude, which is expressed through colours or on the z-axis.

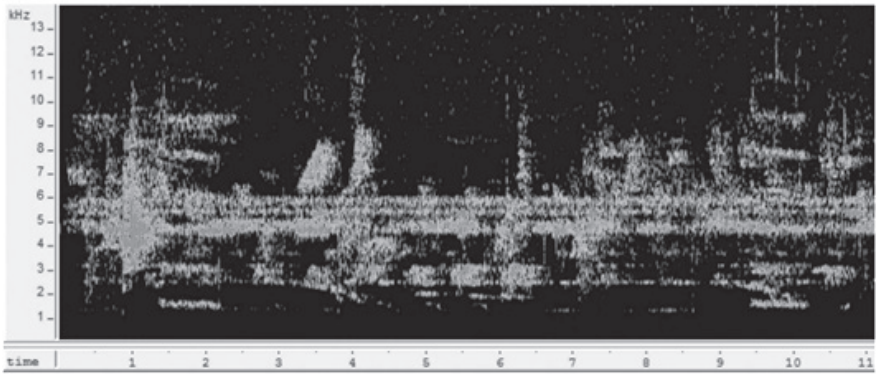

Figure 6. Spectrogram Graph. (Note: The graph above refers to an 11-second recording of dawn sounds at La Selva Biological Station in Costa Rica. Birds and insects create a variety of sounds between 1kHz and 12kHz. Considerable biophonic activity is noticed between 4 and 6kHz. Crickets stridulate at 4.7, 5.3 and 6.0kHz, while raindrops can be heard through the sounds below 2kHz (example of geophony). Source: Pijanowski et al. 2011, p. 205).

Faced with the understanding of the types of sounds and their sound qualities, the need for some procedures for working with soundscape is emphasized, such as recording the sounds and analysis through specific software and music production software –such as Raven, Wave Surfer, Seewave and Song Scope– where it is possible to manipulate and filter the sound spectra of interest.

From the manipulation and interpretation of these types of sound representation it is possible to develop other geometric shapes through the logic of computer programming or parametric modeling.

Thus, the association of sound to Biomimicry would first require a thorough analysis of sound, from the point of view of its composition, graphic representation, and mathematical and biological properties for subsequent transfer of principles amenable to emulation perceived from the collection of sounds from the soundscape.

This process may require a subjective transposition of sound to shape through graphic and mathematical analysis, but it can also be objective when associating a particular sound to a specific shape and/or function (shape of the biological phonatory system that produces the sound, or the behavior of this system in the process of sound production, for example).

In addition to these executable forms, the transfer of sounds to architecture, through Biomimicry, can be based on the Sound Analogy that will be addressed and developed in the thesis that originated this article.

Biomimicry, through Sound Analogy, intends to investigate the sounds emitted in nature. These sounds would be translated, through digital systems into geometric shapes or patterns, which could be used for the development of architectural structures.

To capture the sounds from nature, it is important to define the types of sounds relevant to the research. For this research, it will be considered the sounds referring to Biophony and Geophony (sounds from nature), and Anthropophony and Technophony (non-natural sounds, but that sometimes are present and audible in the natural soundscape and impact the environment surrounding nature).

Thus, as a means of approach for the development of the research, it is intended to combine sounds and architecture through parametric design resources through visual programming logic. For this, there are already available some plug-ins that allow working with sounds, such as Mosquito and Firefly, allowing the execution of several tasks that enable the graphic visualization of sounds *(See Figure 7)*.

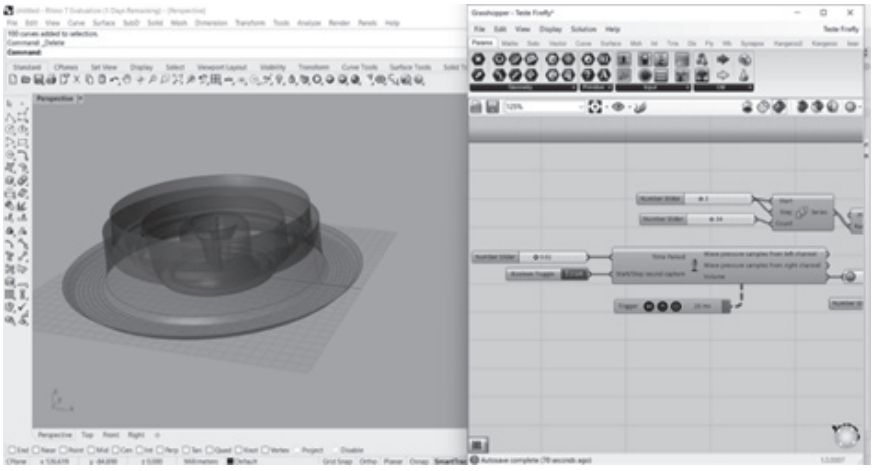

Figure 7. Graphical representation of sound waves through translation by the Firefly plug-in. (Note: For this type of representation were used the 3D modeling software Rhinoceros (window on the left) as a visualization environment of the code implemented in the visual programming environment Grasshopper (window on the right). Source: Prepared by the author, 2022).

That is, it is perceived through parametric design the possibility of developing computational experiments using sounds and following the molds of the conventional biomimicry design process that uses visual inspirational elements. Thus, through these computational experiments it is possible to develop projects or parts of them in the field of architecture and design.

Experiments that combine computational design and the biomimicry design process are already well developed and have become the result of theses, workshops, and academic programmes that seek to ally architecture and design to the technological advances of the ongoing time. The ICD/ITKE[7] in Germany, for example, commonly develop pavilion projects that seek inspiration from nature for the design and construction processes *(See Figure 8)*, besides demonstrating the most recent advances in computational design, robotic production processes in architecture, and materials development.

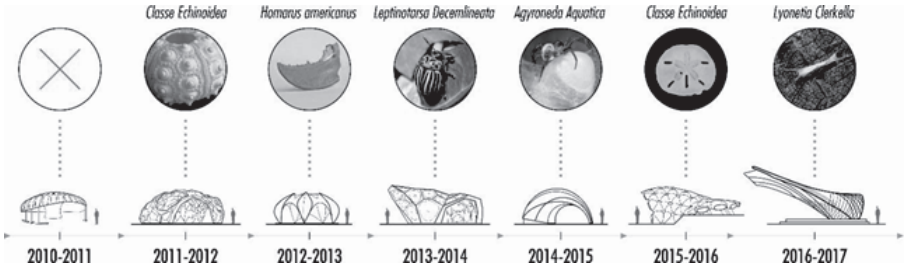

Figure 8. Diagram of the projects developed by ICD/ITKE and their respective natural inspirations. Note: Illustration of only the pavilions developed between 2010 and 2017. Source: Soares & Quintella, 2018, p. 3).

The parametric design, in turn, based on algorithms, would help in the design conception to create shapes based on the sounds processed from previously mentioned tools in a visual programming environment. Besides this, allied to the morphological development, it is still possible to integrate performance variables and generative design tools in the project development.

Conclusions

Normally, creative practice is guided by what an individual can capture from the world around him, according to his more developed senses, and the emotions experienced or imagined. Commonly, 'seeing' and 'observing' make more sense as an inspirational source

because it is a more tangible reality, as well as having a much more culturally trained and valued sense by society over ages (sight is associated with scientific observation, the proof of the existence of a thing is based on the fact that it can be seen). On the other hand, 'listening' and 'hearing' is a little deeper and requires another type of understanding, since the mind needs to translate the emotion caused by sound waves and express this feeling. This particular language of expression can bring to reality different artistic forms that do not necessarily fulfill a pattern or establish a formal language of expression, since this process of translation is something personal, interpretative, spontaneous, and momentary.

When relating this form of audible expression with Biomimicry, it is perceived that the functional and symbolic analogies (De Freitas; De Arruda, 2018, p. 77) are the ones that are most related. While the first understands the sound interpretation as a functional characteristic of living beings as a means of warning, the second one already addresses the semantic dimension and does not require a faithful representation of an element of nature. Given these characteristics, it is clear that the concept of Sound Analogy would allow a clearer approach to the relationship between Biomimicry and Soundscape.

When compared to visual records, Deichmann (2018, p. 715) discusses the possibility of animal sound recordings serving as an attractive and engaging tool for the public. What draws attention in photographic records considered 'camera traps' is the charismatic spontaneity of animals, yet he points out that sounds can be equally compelling. Thus, art originating from the natural soundscape is a tool for the dissemination of science, being able to provide engaging experiences on an emotional level and raising public awareness of the importance of Ecoacoustics and the health of ecosystems (Monacchi & Krause, 2017, p. 311).

As for the previously mentioned computational devices for the development of morphological experiments through sounds, it is also suggested the possibility of transposing the sounds into graphic elements, more precisely architectural and design elements, through programming languages developed by scripts and the Machine Learning resource.

Notes

1. Kilimanjaro: it is the highest mountain in Africa, and a dormant volcano in Tanzania. The mountain and the surrounding forest have a very rich fauna.

2. Amazon: it is a biome that is covered by the Amazon tropical rainforest and comprises most of the Amazon basin in the South America continent. This biome covers areas in Bolivia, Brazil, Colombia, Ecuador, French Guiana, Guyana, Peru, Suriname, and Venezuela.

3. PUC-Minas: *Pontifícia Universidade Católica de Minas Gerais* (Pontifical Catholic University of Minas Gerais).

4. UFRN: *Universidade Federal do Rio Grande do Norte* (Federal University of Rio Grande do Norte).

5. *Arctium lappa*: commonly known as greater burdock, it is a specie of plant belonging to the family of *Asteraceae.*

6. *Victoria amazonica*: specie of flowering plant belonging to the family of the *Nymphaeaceae,* commonly called water lily.
7. ICD/ITKE: *Institute for Computational Design / Institut für Tragkonstruktionen und Konstruktives Entwerfen* (Institute of Building Structures and Structural Design).

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Resumen: La Biomímesis es una metodología útil para desarrollar soluciones eficientes a los retos humanos en diversas áreas del conocimiento, incluyendo la arquitectura y el diseño, basándose en observaciones de la naturaleza y para ello la literatura ya aborda diferentes métodos como las analogías. Así, este artículo parte de la percepción de que la Biomímesis y sus analogías se inspiran en la dimensión visible de la naturaleza, como formas y funciones de determinado elemento natural. Con esto, existe la posibilidad de discutir la Biomímesis desde el punto de vista audible de la naturaleza, rescatando el pai-

saje sonoro como elemento natural inspirador y aumentando el alcance de las analogías discutidas en la literatura.

Palabras clave: Biomímesis - Sonidos - Paisaje sonoro - Analogías - Diseño arquitectónico - Diseño bioinspirado

Resumo: A biomimética é uma metodologia útil para desenvolver soluções eficientes para desafios humanos em várias áreas do conhecimento, incluindo arquitetura e design, com base em observações da natureza e para isso a literatura já aborda diferentes métodos, tais como analogias. Assim, este artigo parte da percepção de que a Biomimicry e suas analogias são inspiradas pela dimensão visível da natureza, como formas e funções de determinado elemento natural. Com isto, há a possibilidade de discutir a Biomimicry do ponto de vista audível da natureza, resgatando a paisagem sonora como um elemento natural inspirador e aumentando o alcance das analogias discutidas na literatura.

Palavras-chave: Biomimética - Sons - Paisagem sonora - Analogias - Design arquitetônico - Design inspirado na bioinspiração

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