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(NEURO)ARCHITECTURE

(NEURO)ARCHITEKTURA

Abstract

Architecture is a perceptual process in which space interacts with the human body and nervous system. At the same time, this experience is neither uniform over time nor entirely individual. Architecture is therefore a dynamic phenomenon in which time, movement, and individual perception and interpretation play a key role. From a neuroaesthetic perspective, the experience involves multisensory perception and emotional responses that modern research equipment can measure. This provides insight into this aspect of experiencing architecture. This article outlines architecture as a process of perception from a neuroaesthetic perspective. It shows how time, movement, and the sequential nature of experience influence the perception of space, and how neuroaesthetics helps describe the relationships between architectural stimuli and nervous system function.

Keywords: *experience of architecture, memory of places, movement and time, multisensory perception, neuroaesthetics*

Streszczenie

Architektura jest procesem odczuwania, w którym przestrzeń oddziałuje na człowieka poprzez ciało i układ nerwowy. Nie jest to jednocześnie doznanie jednolite w czasie i wyjątkowo indywidualne. Architektura jest więc dynamicznym zjawiskiem, w którym kluczową rolę odgrywają czas, ruch oraz indywidualna percepcja i interpretacja. W ujęciu neuroestetyki doświadczenie angażuje wielozmysłową percepcję oraz reakcje emocjonalne, które można zmierzyć za pomocą nowoczesnej aparatury badawczej. Umożliwia to uzyskanie wglądu w ten aspekt odczuwania architektury. Artykuł jest próbą zarysowania tematu architektury jako procesu odczuwania w ujęciu neuroestetyki. Dąży do określenia, w jaki sposób czas, ruch i sekwencyjność doświadczenia wpływają na odbiór przestrzeni, a także jak neuroestetyka pozwala opisać relacje między bodźcami architektonicznymi a funkcjonowaniem układu nerwowego

Słowa kluczowe: *doświadczenie architektury, neuroestetyka, pamięć miejsca, percepcja wielozmysłowa, ruch i czas*

1. INTRODUCTION

Architecture is usually discussed as if it were merely an artefact, assessed based on images that are often carefully selected and framed. Yet no one experiences a building solely through its visual aspect, as shown in photographs. One approaches a building, enters it, walks through it; sometimes one touches it, hears it, and occasionally smells it. One experiences it in the rain and in the sunshine, in a hurry and at a leisurely pace, traversing its interiors, whether one is twenty or seventy years old. Each time, we consciously register

a not insignificant number of sensations, and the selection of these determines how we will remember it.

It is, therefore, an encounter with architecture as a process in which space interacts with the human being through the body and the nervous system. And this experience is not uniform over time, but exceptionally individual. One might therefore argue that architecture is, paradoxically and contrary to its traditional description, a dynamic phenomenon in which time, movement, and individual perception and interpretation play a key role. A building is not so much viewed as it is experienced, and what remains of it is first and foremost a physical reaction of the body, and only then a judgment.

Advances in modern technology and the development of research tools used in neuroaesthetics allow closer analysis and description of the biochemical aspects of this process. The experience of architecture, which engages multisensory perception – and specifically certain bodily reactions – can indeed be measured using research equipment: functional imaging, mobile electroencephalography, eye-tracking and skin conductance response testing.[1] This is by no means a comprehensive measurement of objective, individual perception and evaluation of architecture. It is, however, a method that provides partial insight into the process – and, more specifically, into the part of it related to the body's immediate reactions. The data remain fragmentary, and their interpretation is sometimes contentious. Still, their analysis allows subsequent assessments and descriptions – as processed by the viewer's consciousness – to be grounded in specific physical data. Statements describing various types of reactions to architecture, such as 'this space encourages relaxation' or, conversely, 'it evokes anxiety', are no longer merely rhetorical.

This article outlines the subject rather than presenting a comprehensive analysis. Neither the scope nor the number of studies in this field, nor the length of this paper, allows for such a comprehensive analysis. The theses presented emerge from the interaction of two methods, which forms the article's main premise. This premise outlines, primarily at the level of meta-analysis, the relationship between phenomenological description – widely used in research on the perception of architecture – and neuroaesthetic research, which is generally presented as a relatively new tool in this field.

2. THE PHYSICAL DIMENSION OF ARCHITECTURE

2.1. MODULOR – DREAMING OF A STANDARD

The quest to define the ideal – the 'typical' – human being, who serves as a point of reference for all kinds of design projects, is not a new idea. Its popularity over the centuries shows, among other things, how useful this idea has been to designers. From the Vitruvian Man to the non-existent ideal inherited from modernism – the Modulor. Behind all these models lies a belief in a certain universal user. On the one hand, tools for the architect on their journey to establish the principles of architectural design; on the other, a user with standardised needs. These are unreal entities, for whom the adopted guidelines make it possible to meet

[1] A. Chatterjee, O. Vartanian, *Neuroaesthetics*, "Trends in Cognitive Sciences" 2014, no. 18(7), pp. P370–378, https://neuroaesthetics.med.upenn.edu/assets/user-content/documents/publications/chatterjee-vartanian-2014-01.pdf (access: 10.06.2026).

the real needs of residents and users, even if, in principle, they deviate from the accepted model. Modulor derived a scale for architecture based on a six-foot man – equivalent to 1.829 metres – and presented it as a universally applicable tool.[2] The ambition was humanistic, but the result became an abstraction.

The issue here is not to reject systems of standardised proportions – which are very useful design tools. The aim is rather to realise what they are for and what they describe. This system describes an object, not an experience; and if experience arises as an interaction between the body and space, then the body's distinctiveness is not a disturbance that needs to be averaged out. It is, rather, an immanent feature of architecture, thus aligning with Gibson's concept of affordance in a general sense. In other words, the environment offers a variety of possibilities for action, but these always dependent on the capabilities of a specific organism, even if the individual in question is not aware of them.[3]

The assertion that sight itself is overrated in contemporary architecture is neither new nor particularly controversial. This criticism is now a classic position in architectural theory. As its leading exponent, J. Pallasmaa, argues, the hegemony of sight has impoverished architecture, whilst touch connects us to the world, for the other senses are merely variations of it.[4] The argument is undoubtedly one worth repeating and reflecting upon time and again. For whilst it has found its place and significance in theoretical discourse, it has not really been adopted in practice. Buildings are still mainly assessed based on photographs or visualisations, and competition juries reward what looks good in a photograph.

Meanwhile, other types of stimuli exist, and suppressing them is not justified in every case. Paradoxically, the nervous system needs stimulants, albeit to a certain extent. And the present day shows that, despite being bombarded with content almost constantly, complete isolation is not necessarily a good thing either – especially in the long term. However, managing quantity and quality over time is essential. Sound is a good example here. Architecture functions by creating sounds – whether quiet or loud – and by amplifying or dampening them as required. Reverberation can be irritating, but it can also be enchanting. In a concert hall, acoustics do not merely accompany the art created within it; they are a fundamental prerequisite, and the ability to shape and use them forms the basis of the musical experience.

At the same time, although acoustics are often the most important aspect in the perception of an interior, they are frequently designed last, when the building's geometry has already been finalised. Developing them properly boils down to material choices and faces significant constraints. They also shape how the other senses perceive spaces. Reverberation depends on the room's shape and the materials used. Therefore, choosing a stone floor or wooden wall cladding is a decision about shaping sound. Still, it also affects visual perception – even if it does not directly concern it.

Of course, these observations extend to the other senses. Materials used in a building encourage interaction – we want to touch them and, in doing so, explore them by running our hands over a brick or the rough surface of concrete. This is how we come to understand the age and texture of a surface – experiencing the materiality of architecture most intensely

[2] Le Corbusier, *The Modulor: A Harmonious Measure to the Human Scale Universally Applicable to Architecture and Mechanics*, Faber and Faber, London 1954, https://archive.org/details/modulorharmoniou0000leco_w9w5 (access: 10.06.2026).

[3] J.J. Gibson, *The Ecological Approach to Visual Perception*, Houghton Mifflin, Boston 1979, https://archive.org/details/ecologicalapproa0000gibs (access: 27.05.2026).

[4] J. Pallasmaa, *Oczy skóry. Architektura i zmysły,* Instytut Architektury, Kraków 2022.

and straightforwardly. Reactions to temperature and air movement are also significant. The sensation of a draught or the warmth of a sun-drenched bench are surely the most vividly remembered impressions of a space. These impressions are experienced both in varying light and in darkness, without the aid of sight. Light is not a single state, but a cycle; thus, the same room becomes several different rooms between morning and dusk and between dusk and dawn, at every hour of the day, bringing new sensations to the occupant.

And yet olfactory sensations are just as important, if not more so. This stimulus reaches the limbic structures via a shorter pathway than other stimuli, which is why a scent evokes memories so powerfully. Sometimes we remember spaces with intense smells (such as cellars) better than attractively designed rooms, even though architects designed nothing of interest there. This 'Proustian madeleine' effect is strongly present in assessing experiences at the interface between the user and architecture, although it is rarely utilised.

Regardless, however, of which of the senses we are examining, it must be acknowledged that, as Peter Zumthor writes, our first impression of a space is an emotional and sensory whole, comprising temperature, sound, the presence of materials and light, long before any intellectual analysis takes place.[5]

3. *ARCHITECTURA FUGIT*

It is something of a truism to say that a building cannot be seen in its entirety at first glance. This is true in a literal, physical sense, but also because observation is temporal. As time passes, the building changes – or at least our perception of it does. This occurs simultaneously on several levels: a cyclical one, linked to the succession of times of day and seasons; and a linear one, linked to the passage of time and the functioning of both the building and the observer within it. Furthermore, exploration itself is a process, not a static point in time, but a directed series of successive impressions.

This aspect is also the subject of research in neuroaesthetics. In experiments using mobile electroencephalography, participants walk through virtual interiors, and the recordings show that the geometry of the space alters brain activity during the very act of passing through it.[6] More important and more interesting than a single result is the transfer effect – a shift in the object of study: from the image of the interior to the image of one's passage through it.

Research and experience indicate that a building's layout should form a kind of labyrinth. A labyrinth, however, is understood here in a specific sense – not as chaos or disorientation within spaces, but as a structure of choices and the discovery of unexpected novelty hidden behind successive decisions. The layout does not reveal all the information, yet remains clear enough to guide the next decision. In this sense, a good labyrinth does not lead one astray but guides one through tension and orientation, sustains curiosity, and ultimately reveals the way out.

The fundamental difference here lies in the challenges. Being confined within a space that offers no information acts as a deterrent, instilling a sense of threat. In studies using

[5] P. Zumthor, *Myślenie architekturą*, trans. A. Kożuch, Karakter, Kraków 2010.

[6] M. Banaei et al., *Walking through Architectural Spaces: The Impact of Interior Forms on Human Brain Dynamics,* "Frontiers in Human Neuroscience" 2017, art. 477, https://www.frontiersin.org/journals/human-neuroscience/articles/10.3389/fnhum.2017.00477/full (access: 15.06.2026).

magnetic resonance imaging, such interiors more often prompted participants to leave immediately. This was accompanied by activation of the anterior cortex, in an area associated with the amygdala.[7]

Introducing information into the system had the opposite effect. Built-up tension, with the possibility of regulating it, or an element of uncertainty that still provides a point of reference, are arrangements that make people linger and even arouse their curiosity and engagement. In the same studies, participants rated such interiors as more beautiful. These interiors activated the structures responsible for visual-spatial exploration, and curvilinear contours fared better than straight ones.[8]

A labyrinth designed this way has another advantage: it forces a choice, and choice, as noted above, engages the visitor. Choice without orientation is not a labyrinth, but chaos, and the nervous system cannot tolerate chaos for too long.

At the same time, none of the above findings define spatial form. They point to something else – something more nuanced and cautious, and perhaps also more useful. The nervous system's reactions are a response not so much to the geometry itself, but to what that geometry says about the possibility of movement, observation and the clarity of communication – the exit. Architecture should intrigue us, rather than provide simple answers.

4. TRACKING EMOTIONS

Neuroaesthetics presents perception of a building as the interaction of three systems: the sensorimotor system, the emotional-evaluative system (based on reward circuits), and the semantic system, which brings context, expectations, and cultural knowledge.[9] These systems do not operate sequentially and do not carry the same weight in every encounter. This goes some way towards explaining why architecture is so difficult to talk about. The reaction goes beyond the intellectual; it begins as a response and manifests in the body as changes in posture, breathing, heart rate, and skin conductance, and only later reaches consciousness, where the observer's cognitive framework overlays it.

Field research also shows that a monotonous, featureless façade reduces passers-by's arousal and mood, while a varied façade of the same length has the opposite effect.[10] Boredom has its own physiology.

Emotions in architecture have another characteristic. They rarely occur in isolation and rarely linger. A momentary surge of tension is followed by a moment of calm, and these sequences occur in various patterns. Their progression can, however, be designed, whilst it is impossible to design a specific emotion in a specific person.

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[7] O. Vartanian et al., *Architectural Design and the Brain: Effects of Ceiling Height and Perceived Enclosure on Beauty Judgments and Approach-avoidance Decision,* "Journal of Environmental Psychology" 2015, no. 41, pp. 10–18, https://doi.org/10.1016/j.jenvp.2014.11.006 (access: 18.05.2026).

[8] O. Vartanian et al., *Impact of Contour on Aesthetic Judgments and Approach-avoidance Decisions in Architecture*, "Proceedings of the National Academy of Sciences of the United States of America" 2013, no. 10, suppl. 2, pp. 10446–10453, https://doi.org/10.1073/pnas.1301227110 (access: 13.007.2026).

[9] A. Chatterjee, O. Vartanian, *op. cit.*

[10] C. Ellard, *Places of the Heart: The Psychogeography of Everyday Life*, Bellevue Literary Press, New York 2015.

At the same time, it may be desirable for architecture not to evoke any emotions at all, or at least not emotions that are too extreme or intense. This caveat matters because neutrality is sometimes an end in itself and sometimes a means to an end, pursued to achieve significant benefits.

5. MEANING AND MEMORY

Our experience, including in architecture, is not 'pure'. Our memory functions not only as an archive but also as an interpretative mechanism. Afterimages of space – fragmentary, blurred, sometimes distorted – influence how we understand the form, function and atmosphere of buildings.

Hence a simple conclusion: different users perceive the same space differently. For some, it may feel familiar, becoming a place of rootedness; for others, it will remain alien or indecipherable. This is why Bachelard described this mechanism, treating the house not as an object but as a structure of intimate memory, in which the cellar and the attic are psychological categories before they become stories.[11] Norberg-Schulz, by contrast, addressed this more broadly, offering a collective perspective. For this author, a place's identity forms from the characteristics that accumulate within it, and architecture's task is to give them concrete form.[12]

Of course, memory also influences the designer's decisions. We draw on what we have seen, experienced, and remembered, even if we cannot pinpoint specific sources. This is not necessarily a flaw or a lack of originality; it is the only means of access and the only material available to the designer. Nevertheless, it is worth knowing what one is using, because an afterimage taken without reflection returns as a quotation, whilst one taken consciously returns as a transformation.

6. MEASURABLE AND UNMEASURABLE

Modern equipment allows us to gain insight into many aspects of the body's response to external stimuli – including those related to the environment in which we live. Functional magnetic resonance imaging pinpoints evaluative responses and decision-making in reaction to controlled architectural stimuli. Mobile electroencephalography, combined with motion tracking and a virtual environment, records brain activity whilst walking, and this is essentially the only way to examine the temporal and sequential aspects of spatial cognition. Eye-tracking examines fixation sequences and gaze duration, revealing where attention is actually directed. Meanwhile, the simultaneous measurement of skin conductance response, heart rate variability, and cortisol levels describes arousal and stress load, providing insight into the accompanying emotions. Finally, VR offers what traditional architectural research cannot: the ability to vary a single, selectively chosen variable.[13] [14]

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[11] G. Bachelard, *The Poetics of Space,* Penguin Classics, New York 2014.

[12] C. Norberg-Schulz, *Genius Loci: Towards a Phenomenology of Architecture*, Rizzoli, New York 1980, https://archive.org/details/geniuslocitoward0000norb (access: 5.06.2026).

[13] M. Banaei et al., *op. cit.*

[14] O. Vartanian et al., *op. cit.*

The results themselves may be interesting in isolation. Still, together these methods allow us to establish something of immense importance, underpinned by physical evidence: architectural features are not aesthetically neutral, and visual complexity influences users' judgments, physiological state, and readiness to engage with or disengage from the building.

The ease with which physical information can be obtained also presents certain risks. Average preference data can easily be translated into design rules. In such a case, the result will be optimised architecture – effective, but not necessarily interesting or human. In this instance, it appears as a statistical successor to the Modulor. Neuroaesthetics does not replace design judgment or phenomenological description. It tests and constrains, indicating when an intuition is likely to be shared, when it is ours alone, and when a decision has consequences that the drawing does not reveal.

7. CONCLUSIONS

In summary, architecture should be understood as a process of perception, as a dynamic phenomenon, rather than as an object that remains unchanged over time, because we perceive it through multiple senses. Architecture is a process, whilst a plan and a section are a record of possible trajectories and scenarios of perception, understood as a structure of choices. In this sense, the experience of space is, above all, about emotions and meanings. These evoke transient states through the nervous system, which is already burdened with memory. This is why the same space is sometimes perceived in completely different ways. The normative body, on which a large part of the theory of proportion is based, does not exist, and differences stem from experience. Neuroaesthetics provides a real, albeit partial, insight into this issue and shows how our reactions influence our assessment. In practice, this means a shift in the focus of our work. For we do not merely compose forms for viewing, but sequences of multisensory situations that are dissimilar to one another in time.

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[5] Ellard C., *Places of the Heart: The Psychogeography of Everyday Life*, Bellevue Literary Press, New York 2015.

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