POLITECNICO DI TORINO
Department of Architecture and Design (DAD)

Master’s degree program in
ARCHITECTURE CONSTRUCTION CITY

Master’s Degree Thesis

ARCHITECTURE AND EMOTIONS: BRIDGING SCIENCE AND ART IN THE DESIGN OF HUMAN EXPERIENCE

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“

Plasson [the artist]: The sea is difficult.

Bartleboom [the scientist]: ...

Plasson: It’s difficult to know where to begin. You see, when I used to do portraits, portraits of people, I used to know where to begin, I would look at those faces and I knew exactly [...] When I painted people’s portraits, I used to begin with the eyes. I would forget all the rest and concentrate on the eyes, I would study them, for minutes and minutes, then I sketched them in, with a pencil, and that was the secret, because once you have drawn the eyes It happens that all the rest just follows, it’s as if all the other pieces slip into place around that initial point by themselves

Plasson: and this is where the real problem lies, the problem that drives me mad, lies exactly here (stop)

Bartleboom: ...

Plasson: ...

Bartleboom: Do you have an idea where the problem lies, Plasson?

[...]

Plasson: The problem is, where the dickens are the eyes of the sea?

Bartleboom: ...

Plasson: ...

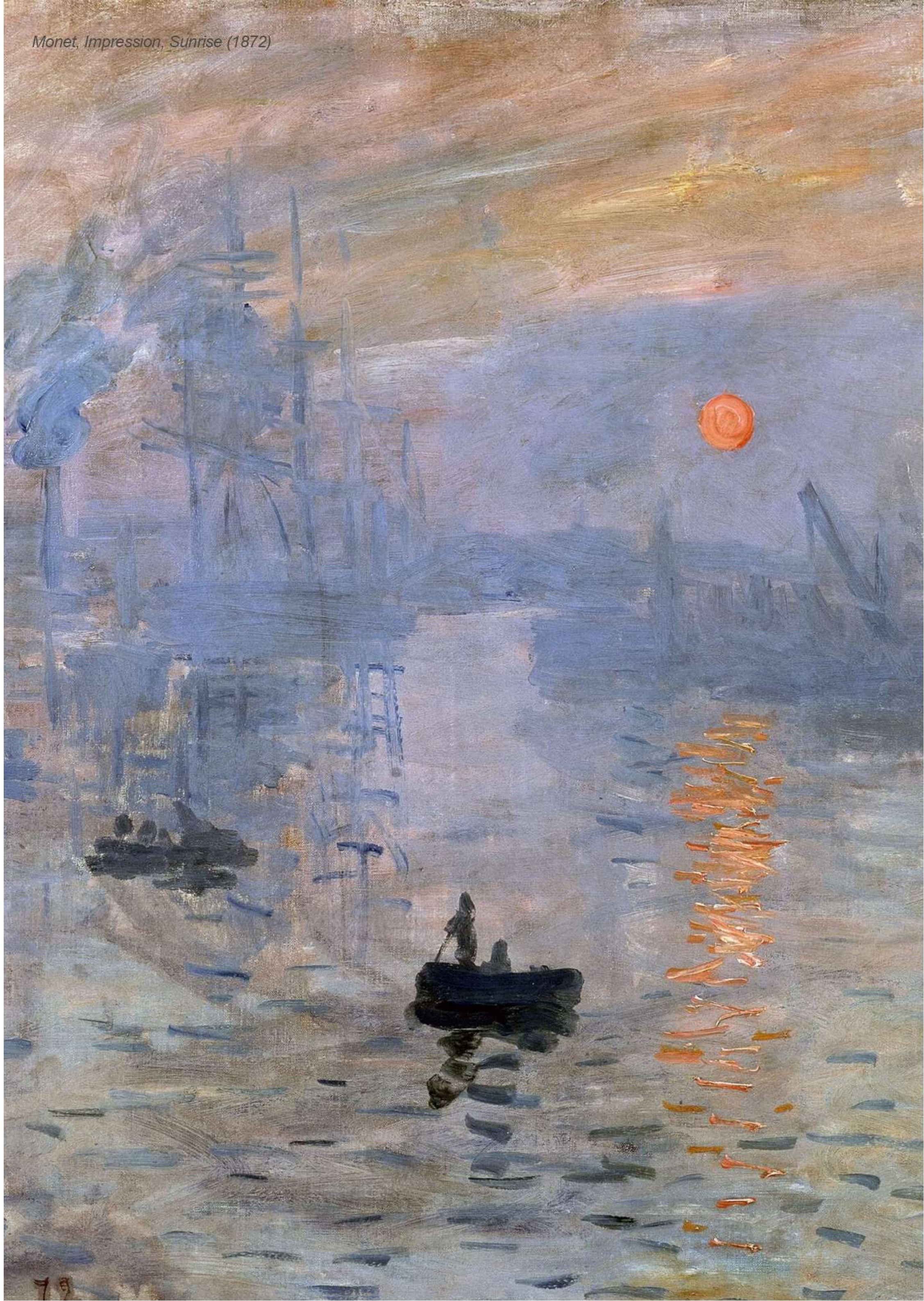
Bartleboom: ...

Plasson: This is the problem: Where does the sea begin?

”

From Ocean Sea by Alessandro Baricco

Monet, Impression, Sunrise (1872)



ACKNOWLEDGMENT

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DEDICATION

To my parents and family, who have always believed in me, dedicated themselves, and endured my absence to help me achieve my goals. You have given me your unconditional love and support, and I feel your presence here with me, despite your being halfway across the world.

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ABSTRACT

This thesis explores the intersection of architecture and emotions, investigating how spaces can be designed to evoke specific emotional responses in users. By employing neuroscientific methods like EEG and Mobile Brain/Body Imaging (MoBI), it delves into the nonconscious and perceptual processes that influence how individuals experience architectural atmospheres. Two contrasting spaces were designed—one to evoke negative emotions and the other to stimulate positive feelings. The findings highlight the power of subtle design manipulations, such as the distortion of distance and lighting, in shaping emotional responses. This research contributes to the field of neuroarchitecture by demonstrating that while emotions are subjective, architectural design plays a significant role in guiding emotional experiences. Ultimately, the study emphasizes the potential for architecture to move beyond aesthetics and functionality to engage deeply with the psychological and emotional well-being of its users.

KEYWORDS

Architecture, Emotions, Ecological Psychology, Neuroscience, Neuroarchitecture, Phenomenology, Human Perception

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1. INTRODUCTION

1.1 The Specific Focus of This Thesis

While the fields of neuroscience, neuroarchitecture, and the use of technologies like MoBI and fMRI offer extensive frameworks for understanding the interaction between architecture and human perception, this thesis narrows its focus to the neuroscientific exploration of atmospheric perception in architectural spaces. Specifically, it investigates how architectural elements—such as window geometries, spatial forms, and sensory stimuli—affect emotional and cognitive responses. The research emphasizes the role of unconscious processes and perceptual priming in how individuals experience architectural atmospheres. Through the integration of neuroscientific methods, such as EEG and MoBI, and the study of first-person and third-person perspectives, this thesis aims to contribute new insights into how architecture can be designed to engage both conscious and nonconscious adaptive skills. By honing in on the nuanced effects of architectural environments on human emotional and behavioral responses, the thesis adds a new layer to the understanding of perception-action dynamics within neuroarchitecture.

1.2 Key Bibliographic References

In developing a comprehensive understanding of the interplay between architectural design and human emotions, several seminal works provide the foundation for this thesis. These references encompass interdisciplinary perspectives from neuroscience, psychology, philosophy, and architectural theory, each contributing unique insights into how built environments affect human experience.

Zakaria Djebbara and his colleagues have conducted extensive research on the dynamic interactions between architectural environments and human cognition. Their studies employ advanced methodologies, including virtual reality simulations and sensor-based data collection, to investigate how different spatial configurations affect cognitive load and emotional states. Djebbara’s work underscores the necessity of designing immersive environments that not only meet functional requirements but also enhance mental well-being and cognitive performance. By exploring how architectural elements can influence cognitive processes, Djebbara’s research contributes to a deeper understanding of the symbiotic relationship between space and human experience (Djebbara et al., 2019).

Complementing Djebbara's findings, Juhani Pallasmaa’s "The Eyes of the Skin: Architecture and the Senses" advocates for a multisensory approach to architectural design. Pallasmaa argues that architecture should engage all the senses, not just vision, to create more holistic and immersive experiences. His emphasis on the tactile and sensory richness of spaces informs contemporary discussions on the emotional and psychological impact of architectural design. Pallasmaa’s work highlights the need for environments that are functionally effective and emotionally engaging, advocating for a design philosophy that considers the full spectrum of human sensory experience (Pallasmaa, 2012).

Similarly, Elisabetta Canepa’s research offers a contemporary examination of the neuroscientific principles underlying architectural design. Her work focuses on how environmental factors such as light, color, and spatial proportions influence neural activity and emotional responses. Canepa’s studies advocate for integrating neuroscience into architectural practice to promote designs that foster positive emotional and cognitive outcomes. Her contributions are significant in bridging the gap between scientific research and practical architectural applications, emphasizing the importance of creating environments that enhance both emotional well-being and cognitive function (Canepa, 2020).

James J. Gibson's "The Ecological Approach to Visual Perception" introduces the concept of affordances, which refers to the potential actions that an environment offers to an individual. Gibson’s ecological psychology framework emphasizes the active role of perception in shaping human interaction with space, providing a theoretical basis for understanding how architectural elements can influence behavior and experience. His work underscores the importance of designing environments that support and enhance natural human activities, highlighting the interplay between perception and the built environment (Gibson, 1979).

John Paul Eberhard’s pioneering work in neuroarchitecture explores the application of neuroscientific principles to architectural design. His seminal contributions focus on how various elements of the built environment can influence cognitive functions and emotional states. Eberhard emphasizes the significance of creating spaces that cater to the neurological and psychological needs of users. By integrating neuroscientific insights into architectural practice, his work advocates for designs that enhance cognitive performance, emotional well-being, and overall quality of life. Eberhard's research provides a scientific basis for understanding the profound impact of spatial configurations on human brain function (Eberhard, 2009).

Tonal Griffero and Peter Zumthor offer profound insights into the sensory and affective dimensions of architectural experience. Griffero's exploration of atmospheric architectures, particularly in "Atmospheric Architectures: The Aesthetics of Felt Spaces," delves into how spaces evoke emotional responses. His work emphasizes the aesthetics of felt spaces and the importance of atmospheres in contributing to overall well-being. Zumthor's "Thinking Architecture" reflects on the tactile and sensory qualities of architecture, advocating for a design philosophy that prioritizes emotional engagement and sensory richness. Together, these works highlight the impact of atmospheric qualities on human perception and underscore the necessity of creating environments that resonate emotionally with occupants (Griffero, 2014; Zumthor, 2010).

The philosophical works of Edmund Husserl and Thomas Fuchs provide foundational insights into the lived experience of architectural spaces. Husserl's phenomenology, particularly as discussed in "The Phenomenology of Internal Time-Consciousness," offers a framework for understanding how individuals perceive and experience time within different environments. Fuchs' "The Phenomenology of the Body" extends this exploration by examining the role of bodily experience in shaping our interaction with space. These philosophical perspectives are crucial for comprehending the subjective and embodied aspects of architectural experience, providing a deeper understanding of how spaces influence human perception and emotion (Husserl, 1991; Fuchs, 2018).

Sarah Robinson's contributions to architectural theory focus on the intersection of phenomenology and neuroscience. Her work explores how sensory experience and embodied cognition influence architectural aesthetics and user engagement. Robinson advocates for a design approach that prioritizes the lived experience of space, emphasizing the importance of creating environments that resonate both sensorially and emotionally with occupants. Her research integrates phenomenological insights with neuroscientific findings, providing a comprehensive understanding of how architectural spaces can enhance human well-being (Robinson, 2015).

Naghibi Rad and colleagues investigate the emotional responses elicited by different window shapes using event-related potentials (ERP). Their study, "Encoding Pleasant and Unpleasant Expression of the Architectural Window Shapes: An ERP Study," reveals that certain window shapes, such as rectangular and circular, are perceived as more pleasant, while triangular shapes evoke negative emotions. This research highlights the significance of geometric forms in architectural design and their impact on emotional well-being, providing empirical evidence for the role of specific architectural elements in shaping emotional responses (Naghibi Rad et al., 2019).

Shemesh and colleagues explore the emotional impact of geometric criteria in architectural spaces through a neurocognitive lens. Their research, "A Neurocognitive Study of the Emotional Impact of Geometrical Criteria of Architectural Space," utilizes physiological measures like EEG and GSR to demonstrate that large, symmetrical spaces are generally more positively received, while disproportionate features can cause distress. This study underscores the critical role of geometric considerations in architectural design, providing a scientific basis for understanding how spatial geometry affects emotional states and overall well-being (Shemesh et al., 2021).

Martínez-Soto and colleagues examine the neural correlates of restorative environment exposure using functional magnetic resonance imaging (fMRI). Their study, "Exploration of Neural Correlates of Restorative Environment Exposure through Functional Magnetic Resonance," demonstrates how exposure to environments integrated with vegetation activates brain regions associated with stress recovery and attention restoration. This research provides a compelling argument for incorporating green spaces in urban design to enhance mental health, highlighting the therapeutic benefits of nature in architectural settings (Martínez-Soto et al., 2019).

Collectively, these key bibliographic references provide a comprehensive foundation for understanding the interplay between architectural design and human emotion. They offer diverse perspectives, from philosophical and theoretical frameworks to empirical research findings, underscoring the multifaceted nature of this field of study.

2. BUILDNER COMPETITION: MUSEUM OF EMOTIONS

The Museum of Emotions competition, organized by Buildner, is an annual international architecture competition that challenges participants to explore the emotional impact of architectural design. This competition is unique in its focus on how architecture can evoke and manipulate human emotions through carefully considered design elements.

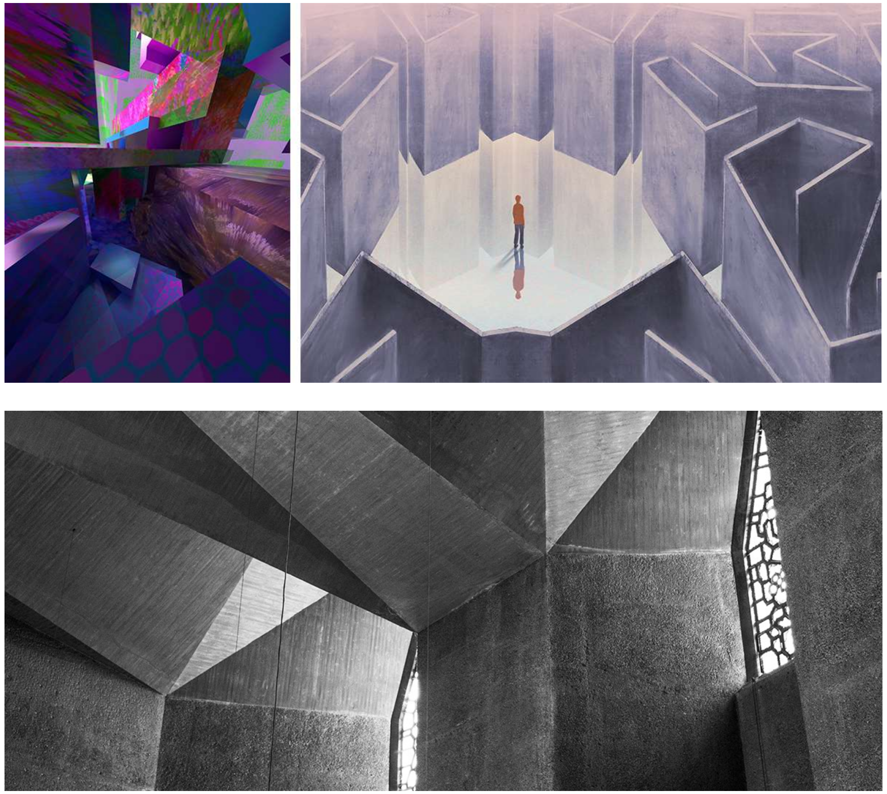


Figure 2.1 Lunching The Competition – Buildner

2.1 Objectives and Brief

The primary objective of the Museum of Emotions competition is to use architecture as a tool to evoke different emotional states. Participants are tasked with designing a museum that includes two separate exhibition halls: one designed to evoke negative emotions and the other to evoke positive emotions. The competition encourages participants to think creatively about how architectural elements such as scale, lighting, color, and material choice can influence emotional responses.

Participants are free to choose any site, real or imaginary, and the scale of their project. This flexibility allows for a wide range of creative interpretations and innovative designs.

Open to both professionals and students, the competition aims to provide participants with global recognition. Winning entries receive monetary awards, publication opportunities, and international exposure, making this competition a stepping stone for architects eager to explore avant-garde concepts and emotional design. Entries are judged on creativity, originality, functionality, and the ability to evoke emotion through the proposed spaces, with an emphasis on how well the project communicates its concept.

For participants like myself, this competition offers not only a chance to develop innovative design solutions but also an opportunity to engage with a fundamental question in architecture: How do spaces make us feel? It aligns perfectly with my personal and academic interests, particularly my ongoing exploration into how architecture can manipulate perception and create emotional atmospheres. The Museum of Emotions competition, therefore, serves as an ideal platform to investigate the connection between space and emotion in a professional setting while contributing to a global architectural discourse.

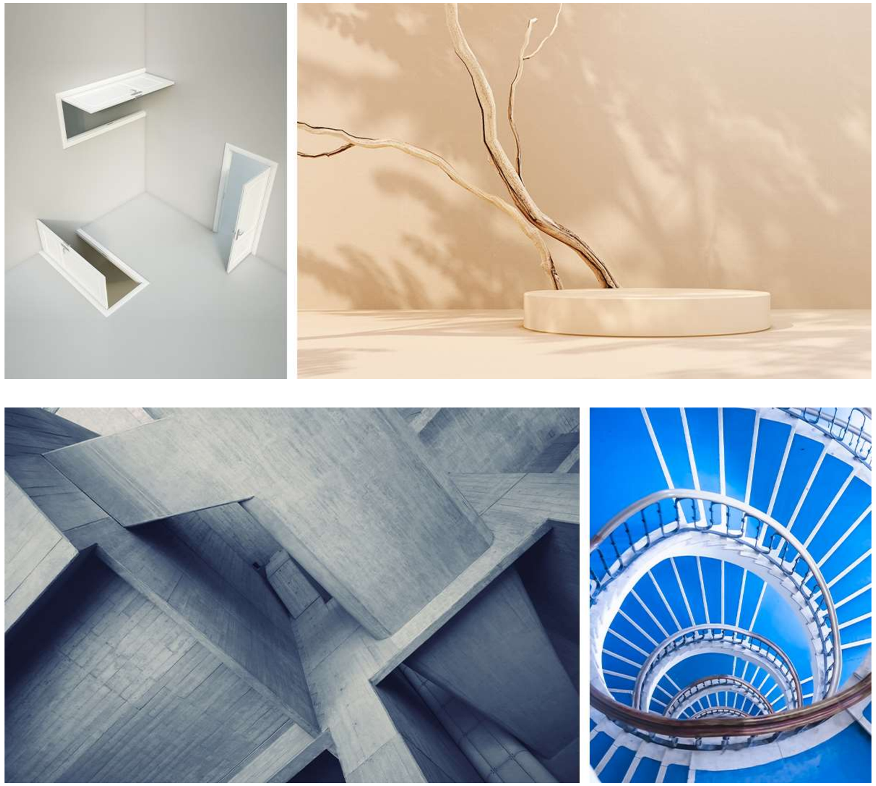


Figure 2.2 Lunching The Competition – Buildner

2.2 Competition Format

One of the unique aspects of the Museum of Emotions competition is that it is a "silent competition." This means that participants must communicate their design ideas solely through visuals, without the use of any text. This format challenges participants to convey their concepts and the emotional impact of their designs purely through imagery, making it a true test of their visual communication skills.

2.3 Jury and Evaluation

The competition is judged by an esteemed panel of international architects and designers. The jury evaluates submissions based on several criteria, including the creativity and originality of the design, the effectiveness of the emotional impact, and the overall quality of the visual presentation. The competition aims to recognize and reward innovative approaches to architectural design that successfully evoke emotional responses.

3. PERSONAL MOTIVATION FOR PARTICIPATING IN THE COMPETITION AND CHALLENGES

3.1 Early Sensitivity to Places and Linking with Architecture

From a young age, I have been fascinated by the emotional impact of different environments. As a child, I often found myself wondering why certain places made me feel uncomfortable while others felt like home. I questioned whether it was the people, the colors, the lighting, or some other intangible quality that influenced my emotional responses.

At the time, I had no clear understanding of why I felt this way. These questions lingered in my mind but remained unconnected to any structured idea or discipline. I simply accepted the emotional responses without fully understanding their origins. It wasn't until later in life, when I began my studies in architecture, that I started to see the link between these early feelings and the built environment itself.

Looking back now, this sensitivity to places has become central to how I approach architecture. My early experiences were, in a way, a foundation for my growing fascination with how spaces affect human emotions. The idea that architecture can evoke powerful emotional responses resonates with the same curiosity that I had as a child, though at that time, I lacked the vocabulary and knowledge to connect these sensations to architectural design.

When I began my bachelor's degree in architecture, I had no clear idea of what to expect. I chose the field because I was drawn to the creative vibes it exuded. However, I soon found myself lost in the vast world of architecture, which is a unique blend of creativity and solid science, aesthetics and function, and thinking outside the box while adhering to standards. I grappled with my identity as an architect, wondering if I was an artist, a designer, an engineer, a builder, a creator, a philosopher, a dreamer, or a realist—or if I needed to embody all these roles to be successful.

Unlike fine arts, where there is more freedom to explore abstract concepts, architecture requires a balance between creativity and practicality. We are obligated to stay grounded in reality, yet we are also asked to be dreamers and innovators. The debate between form following function and function following form further added to my confusion. Different professors had varying opinions, and their feedback ranged from high praise to harsh criticism. Through all this, each student, including myself, struggled to find their architectural personality and define the school of thought they belonged to.

3.2 Returning to Childhood Curiosity

After completing my bachelor's degree and gaining some practical experience in real-life architectural projects, I returned to academia to pursue a master's degree. However, even with this additional layer of knowledge and experience, I found myself revisiting the same questions that had sparked my curiosity as a child. I had studied architecture, practiced it, and gained a deeper understanding of its complexities, yet the core question remained: What is it about certain places that evoke specific emotional responses? What role does architecture play in shaping these emotional atmospheres?

As I advanced in my studies, I realized that this question was not just personal, but also a fundamental aspect of architectural theory and practice. How do we design spaces that connect with people emotionally? How do we create environments that resonate with human emotions on a deeper level, beyond functionality and aesthetics? These questions became more pressing as I engaged with various architectural theories, and I began to see the potential for deeper research into the relationship between architecture and emotion.

This curiosity was reignited in me during my master's studies, as I continued to explore the emotional dimensions of architecture. I started to think about how this aspect could be investigated more scientifically—how architecture influences perception, atmosphere, and emotion in a measurable way. With this renewed focus, I sought a platform that would allow me to explore these ideas in practice.

3.3 Finding the Competition

When I came across the announcement for the international competition focused on designing a **Museum of Emotions**, it felt like a perfect alignment of my personal and academic interests. The competition brief specifically called for a design that evokes contrasting emotional experiences—an idea that directly spoke to my ongoing exploration of the emotional impact of architecture. The challenge was to create a space that would manipulate visitors' emotions using only architectural tools, such as lighting, perspective, scale, and spatial configuration.

This competition provided an ideal opportunity to explore my childhood curiosity in a concrete, professional setting. Participating in it allowed me to test the very ideas I had been pondering for years. I knew that, as an architect, I could intentionally design a space that evokes specific emotional reactions, and that architecture can indeed manipulate human perception and emotion. The more pressing question, however, was **how?**

This challenge became the driving force behind my decision to participate in the competition, offering a unique platform to experiment with these ideas in a real-world context. It not only aligned with my personal curiosities but also provided a framework for the experimental practice I had been seeking. Through this project, I hoped to raise important questions about the relationship between architecture and emotion—questions that would form the basis for the larger scientific research I would pursue in my thesis.

4. DESIGN INTENTIONS AND CHALLENGES IN THE MUSEUM OF EMOTIONS COMPETITION

4.1 Concept Development and Emotional Architecture

When I embarked on the Museum of Emotions competition, I aimed to create a space that could evoke distinct emotional responses solely through architectural elements. My main goal was to manipulate the design in such a way that visitors would experience contrasting emotions as they moved through the museum's two halls—one stimulating positive emotions and the other, negative emotions. However, while this intent was clear, the path to achieving it was far more complex.

The initial challenge I faced was rooted in the very essence of the competition's brief: how could I evoke emotions solely through architecture? I have always been aware that spaces hold the power to influence feelings—whether it be comfort, fear, or awe—but I had never previously approached this as the main purpose of a design. It raised a fundamental question: **how can architecture, without the aid of another aspects manipulate human emotions?** My experience had taught me that light, scale, and materials play important roles in shaping emotional atmospheres, but the challenge here was to distill these elements into a design that would create a direct emotional impact.

4.2 Lack of Precedents and the Role of Science

One of the key difficulties I encountered was the lack of architectural precedents that focus exclusively on this concept. While many buildings unintentionally evoke emotions or rely on external exhibits to enhance an emotional response, few designs are created with the sole purpose of evoking emotions purely through architectural form and space. This scarcity of references meant that I had to work in uncharted territory, blending theoretical research with practical design exploration. There were no clear guidelines or established frameworks on how to approach this type of emotional architecture, which led me to experiment and test different ideas.

In my search for a starting point, I considered integrating scientific research into my process. I explored studies on environmental psychology, cognitive science, and phenomenology in the hope of finding scientific evidence on how spaces affect emotions. For example, I examined how light and darkness can affect human perception, how scale can influence feelings of comfort or unease, and how certain spatial arrangements can prime emotional responses. Yet, as I delved deeper into this scientific approach, I found myself caught in a dilemma. **Should architecture follow strict, evidence-based principles in the same way that science does? And if so, would this reduce the creative freedom that is so essential to design?**

I realized that while science could offer valuable insights, relying too heavily on it could stifle the very creativity that drives architectural innovation. The question then arose: **can we create a set of standards for emotional design, or does the uniqueness of human emotional responses mean that such standards are impossible to define?** Moreover, even if scientific studies provide patterns for how people react to certain spatial conditions, personal emotional experiences vary greatly. A space that makes one person feel awe might evoke anxiety in another. This uncertainty made me question whether architecture can ever be truly prescriptive when it comes to emotional outcomes.

4.3 Balancing Rationality and Intuition

This tension between rational, evidence-based design and intuitive, emotional design became a core issue during my work on the competition. Architecture, as a discipline, often straddles the line between science and art. As architects, we are tasked with creating functional spaces that adhere to structural, environmental, and safety standards, but we are also expected to push creative boundaries, imagining forms that go beyond pure functionality. In the context of the Museum of Emotions competition, this balance became even more pronounced. While I sought to understand how emotional responses could be scientifically anticipated, I also recognized that relying too much on empirical data could undermine the personal, subjective nature of emotions.

This led me to the realization that my design would need to embrace both rationality and intuition. I could not rely solely on measurable data to determine the emotional impact of my design; I would also need to trust my own intuition and creative instincts as an architect. This realization helped me shift my approach, allowing me to experiment with more abstract concepts like perspective manipulation, spatial distortion, and the interplay of light and shadow. By using these elements, I hoped to create a design that could evoke emotions in visitors, even if those emotions could not be precisely predicted or controlled.

4.4 Questions That Arose During the Process

Throughout the design process, several important questions emerged that continue to shape my approach to emotional architecture. First, **how can we create spaces that evoke universal emotional responses, or is this even possible?** Emotions are deeply personal, influenced by individual experiences, cultures, and memories. While some aspects of space—like the use of light or scale—might evoke similar reactions across different people, emotions are ultimately subjective. This raised the question of whether an emotional architecture could ever truly succeed in creating a consistent experience for all visitors.

Second, I questioned **the role of temporality in emotional architecture**. Do emotional responses to space change over time? For instance, does a space that initially evokes discomfort eventually feel familiar after repeated exposure? This made me consider how a museum designed to evoke emotions would function not only for first-time visitors but also for those who visit regularly or return after a period of time. Would the emotional impact of the space diminish, or would it grow stronger?

Finally, I grappled with the question of **how to balance the emotional and functional aspects of architecture**. While my goal in this competition was to evoke emotions, I also had to ensure that the museum functioned as a public space—accessible, safe, and comfortable for visitors. Balancing these functional needs with the desire to create an emotionally charged environment became a central challenge in my design process.

5. ESTABLISHING A SCIENTIFIC FOUNDATION FOR EMOTIONAL ARCHITECTURE

After reflecting on the key questions that emerged during my design process, I realized that if I wanted this competition project to serve as a credible instrument for my scientific research, I needed a solid foundation rooted in scientific principles. This meant looking beyond intuition and aesthetic preferences and seeking reliable methods that could be used to guide the design process, especially when it comes to creating emotional atmospheres.

The challenge of designing for emotions—while acknowledging that emotional responses are subjective—prompted me to explore areas such as psychology, neuroscience, and human perception. I wanted to understand how architecture could influence emotional states in a way that’s not purely artistic but also scientifically informed. My intent was to find principles that could be universally applied, even while leaving room for personal interpretation and cultural variations.

A significant part of this process was recognizing that architecture has long had ties to science. Proportions, light manipulation, spatial arrangement—all of these have roots in empirical knowledge that affect human behavior and emotions. However, I didn’t want to fall into the trap of making architecture too rigid or deterministic. Believing that architecture cannot be reduced to pure science, I was seeking to strike a balance, where scientific insights could inform creativity rather than constrain it.

The natural ways in which the human eye perceives and interprets visual information, often leads to subconscious assumptions about distance, size, and movement in space. Our eyes are drawn to certain patterns, lines, and contrasts, which influence how we perceive depth and spatial relationships. In this chapter, I will discuss how scientific research in such areas, influenced my design process. By grounding my work in both science and creative exploration, I aimed to ensure that the project could act as an experimental tool in my research, one capable of raising new questions and advancing our understanding of emotional architecture.

5.1 Linear Perspective in Ophthalmology and Vision Science

Linear perspective, a concept commonly explored in art and architecture, also holds significant relevance in ophthalmology and vision science. In these fields, linear perspective refers to the way our visual system processes spatial relationships and depth cues, allowing us to perceive the three-dimensional world around us. Understanding linear perspective in the context of vision science provides insights into how the human brain interprets visual information and constructs a coherent sense of distance and depth.

In its most basic form, linear perspective involves the convergence of parallel lines as they recede into the distance, ultimately meeting at a vanishing point on the horizon. This phenomenon mirrors how our eyes and brain interpret depth cues in real life. When we look at objects in the environment, parallel lines, such as roads, railways, or buildings, appear to converge as they move away from us. This visual cue is one of the key factors that our brain uses to estimate depth and distance in a scene. The principles of linear perspective are particularly important in understanding how our visual system constructs a three-dimensional representation of a largely two-dimensional retinal image (Palmer, 1999).

Figure 5.1 Converging parallel lines illustrating the principle of linear perspective and vanishing points – Pinterest.com

The visual system relies on a series of geometric relationships to interpret depth through linear perspective. When viewing a scene, objects that are farther away from the viewer appear smaller, while those that are closer appear larger. This phenomenon, known as size constancy, allows the brain to adjust its perception of object size based on its distance from the observer. For instance, in an urban landscape, buildings at the far end of a street seem smaller than those nearby, despite their actual size being constant. The brain combines this size information with the angles of converging lines (such as roads or train tracks) to form a coherent understanding of spatial relationships (Palmer, 1999).

Figure 5.2 - 5.3 Size constancy showing how objects vary in size when vary in distances - Pinterest.com

Linear perspective also interacts with another important depth cue: texture gradients. As surfaces extend into the distance, the density of the texture appears to increase. For example, when looking at a tiled floor, the tiles closer to the observer appear larger and more distinct, while those farther away appear smaller and more densely packed. The gradual change in texture detail provides the brain with additional information about the scale and depth of the environment. This relationship between linear perspective and texture gradient helps reinforce our perception of space, particularly in situations where other depth cues may be limited (Bruce, Green, & Georgeson, 2003).

Linear perspective is also relevant in the field of virtual and augmented reality, where accurate depth perception is essential for creating immersive experiences. In virtual environments, linear perspective is often manipulated to create the illusion of depth on flat screens. By mimicking the way the human visual system interprets converging lines and distant objects, designers can create convincing three-dimensional scenes on two-dimensional surfaces. This application of linear perspective underscores its importance not just in natural vision but also in artificial visual environments (Palmer, 1999).

Furthermore, the interaction between lighting and linear perspective plays a crucial role in enhancing depth perception. Shadows and highlights provide additional cues about the orientation and position of objects in space. When light falls on an object, it creates areas of brightness and shadow, which the brain interprets as information about the object's three-dimensional form and its distance from light sources. This interaction between light, shadow, and perspective is particularly important in environments with complex spatial layouts, such as architectural spaces or natural landscapes (Bruce, Green, & Georgeson, 2003).

In summary, linear perspective is not just an artistic technique; it is a fundamental aspect of how the human visual system interprets spatial relationships and depth. In vision science, it plays a critical role in monocular depth perception, helping individuals estimate distance and navigate their environment. Understanding how the brain processes linear perspective provides valuable insights into both natural and artificial visual experiences, and it has practical applications in fields ranging from ophthalmology to virtual reality design. The study of linear perspective underscores the complex interplay between geometry, perception, and visual cognition in shaping our experience of the world.

5.2 The principles of Gestalt psychology

The Gestalt principles of psychology provide a critical framework for understanding how the brain processes visual information, and these principles have a profound influence on how people experience and navigate architectural spaces. First developed by German psychologists in the early 20th century, the Gestalt principles focus on how the mind organizes individual elements into coherent wholes (Arnheim, 2004). The foundational principles of Gestalt psychology include **figure-ground organization, proximity, similarity, continuity, and closure,** which collectively explain how we naturally perceive visual and sensory information (Koffka, 1935).

One of the central tenets of Gestalt psychology is the idea that "the whole is greater than the sum of its parts." This means that when we view an environment, our brain does not simply process individual components in isolation; instead, it perceives the overall structure and organization of elements within that space. For example, in a building, people do not merely see separate walls, floors, and ceilings. Rather, they perceive the relationships between these components as part of an integrated, cohesive experience. This concept is fundamental to how architects design spaces to guide perception, evoke emotions, and create specific atmospheres (Arnheim, 2004).

Figure 5.4 Church of the Light, Japan / Tadao Ando – Archdaily Grouping into recognizable forms or shapes, negative space between walls create a cross that becomes illuminated with natural light

One of the most important Gestalt principles is the law of **continuity**, which states that the eye is naturally drawn to follow smooth, continuous lines or curves. This principle is highly influential in architectural design, where lines, edges, and pathways are used to lead the viewer's gaze and body through a space. For example, a long, uninterrupted corridor or a curving façade directs the movement of people through a building in a smooth, guided manner (Ching, 2014). This can have psychological effects, such as creating a sense of flow or movement, or even generating a calming or dynamic atmosphere, depending on how the lines are used. Architects can use continuity to make a space feel coherent and unified, guiding people's attention to key features or directing them toward specific areas, such as an entrance, an atrium, or a window with a view.

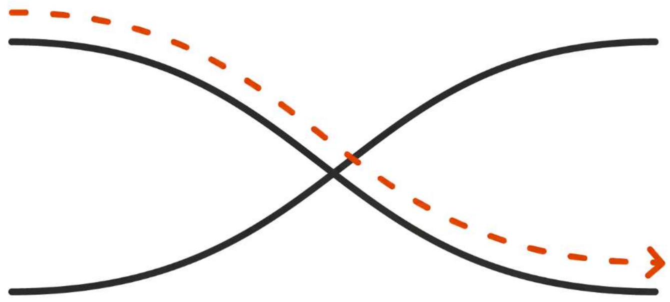


Figure 5.5 Gestalt Rules Continuity – Interaction-design.org

Figure 5.6 Hyōgo Prefectural Museum of Art, 2002. Photo: Off Bombs – Shutterstock

Another critical Gestalt principle is the law of **proximity**, which suggests that elements that are close to one another are perceived as a group. In architecture, this principle can be used to organize space and create a sense of unity among different elements. For example, furniture arranged closely together in a room will be perceived as a single, cohesive unit, which can foster social interaction and a feeling of intimacy. Similarly, in urban design, buildings that are placed in close proximity create a sense of enclosure or community, while large gaps between structures may signal disconnection or openness (Zeisel, 2006). By understanding proximity, architects can manipulate how people perceive the relationships between different elements within a space, creating either cohesion or separation based on the arrangement of objects and structures.

Figure 5.7 Gestalt Rules Proximity – Interaction-design.org

Figure 5.8 Habitat 67 in Montreal, Canada. Designed by architect Moshe Safdie - kadvacorp.com

The law of **similarity** is another Gestalt principle that plays an important role in architectural perception. This principle states that elements that are visually similar—whether in shape, color, or texture—are grouped together in the viewer's mind. In architecture, the repetition of certain forms or materials can create visual harmony and reinforce the design's overall theme. For instance, a building with repetitive vertical columns may convey a sense of order and rhythm, while a space that uses consistent materials, like wood or stone, across various surfaces can create a unified aesthetic. The use of similarity helps establish patterns, which the brain naturally seeks, making the space feel coherent and balanced (Ching, 2014).

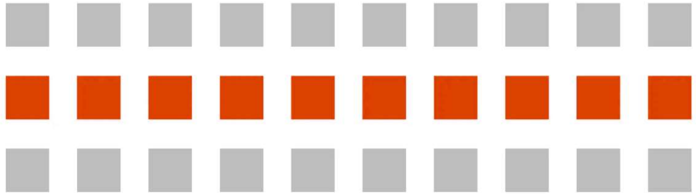


Figure 5.9 Gestalt Rules Similarity – Interaction-design.org

Figure 5.10 ×4 House, Japan / Tadao Ando – wordpress.com

The law of **figure-ground** is another principle that has a significant impact on how we perceive architectural spaces. This principle refers to our ability to distinguish an object (the figure) from its background (the ground). In architectural design, this is often used to create focal points, where a key feature, like a bold sculpture or an intricately designed staircase, stands out against a simpler, less detailed backdrop. The contrast between figure and ground helps the viewer focus on the most important elements of a design while creating a sense of depth and hierarchy within the space. A well-designed figure-ground relationship enhances the clarity of the space, guiding the viewer's attention and creating a more engaging visual experience (Arnheim, 2004).

Figure 5.11 Gestalt Rules Figure-Ground – Interaction-design.org

Figure 5.12 Oscar Niemeyer's Itamaraty Palace Captured by Paul Clemence – Archdaily

The law of **closure** is another Gestalt principle that can be used to great effect in architecture. Closure refers to the brain's tendency to complete incomplete shapes or patterns. In architecture, designers can imply forms or boundaries without fully defining them. For instance, a series of evenly spaced columns might suggest the outline of a wall, even if no actual wall is present. This principle allows architects to create dynamic, open spaces that feel structured, even when physical boundaries are absent. By relying on the viewer's perceptual tendencies to "close the gap," architects can create more flexible, adaptable spaces while maintaining a sense of order and form (Zeisel, 2006).

Figure 5.13 Gestalt Rules Closure – Interaction-design.org

Figure 5.14 Federico Babina's ARCHIPLAN Illustrations Analyze the Floorplans of Master Architects – Archdaily

5.3 The role of light

Lighting is a critical element in architectural design, serving both functional and aesthetic purposes. It shapes how spaces are perceived and experienced, influencing mood, atmosphere, and the overall emotional response of users. The strategic use of lighting can enhance the functionality of a space, guide movement, emphasize important architectural elements, and create a sense of ambiance. Whether through natural or artificial lighting, architects use light as a powerful tool to manipulate the visual and emotional qualities of a building (Ching, 2014).

One of the key roles of lighting in architecture is its ability to define and enhance spatial perception. The interplay of light and shadow helps reveal the form, texture, and depth of architectural features. For instance, the careful positioning of windows or skylights can cast natural light across surfaces, accentuating the three-dimensional qualities of walls, ceilings, or columns. This use of natural light allows for the dynamic transformation of a space throughout the day, as the light shifts in intensity, angle, and color. The changing nature of daylight creates a connection between the building and its environment, contributing to a sense of time and place (Arnheim, 2004).

Figure 5.15 The role of light and shadow in enhancing depth and understanding volumes. - 80.lv.com

Natural lighting, often referred to as daylighting, is essential in creating a sense of openness and comfort. Large windows, clerestories, and light wells allow sunlight to penetrate deep into interior spaces, reducing the reliance on artificial lighting and creating a visually pleasing atmosphere. Natural light can also help establish visual hierarchy by highlighting key areas or features within a space, such as focal points or circulation paths. Additionally, exposure to natural light has been shown to improve well-being and productivity, making it an important consideration in the design of workplaces, schools, and healthcare facilities (Zeisel, 2006). The use of daylight in architecture not only enhances the aesthetic quality of a space but also promotes energy efficiency and sustainability by reducing the need for artificial lighting during the day.

Artificial lighting, on the other hand, provides greater control over the lighting conditions in a space, allowing architects to create specific effects and moods. The choice of lighting fixtures, their placement, and the intensity of light all contribute to how a space is perceived. For example, accent lighting is often used to draw attention to particular objects, artworks, or architectural details, creating focal points and enhancing visual interest. In contrast, ambient lighting provides general illumination for a space, ensuring that it is functional and comfortable for everyday use. The combination of these lighting strategies helps balance the overall lighting composition, making the space both practical and visually engaging (Ching, 2014).

Color temperature, which refers to the warmth or coolness of light, plays a significant role in establishing the emotional tone of a space. Warm light, which has a reddish-yellow hue, is often used in residential and hospitality environments to create a cozy and inviting atmosphere. In contrast, cooler light, which has a bluish hue, is more commonly used in offices, hospitals, and retail environments to enhance alertness and visibility. The careful selection of color temperature helps architects align the lighting conditions with the intended function of the space, ensuring that it supports the desired activities and emotional responses (Zeisel, 2006).

Lighting can also be used to influence the perception of scale within a space. Bright, uniform lighting tends to make a space feel larger and more open, while dim, focused lighting can create a sense of intimacy and enclosure. This is particularly important in environments where the manipulation of scale is key to the user experience, such as theaters, restaurants, or galleries. For example, in a museum, the use of focused lighting on exhibits helps create a sense of importance and intimacy around the artwork, while the surrounding areas remain dimly lit to minimize distractions. This contrast in lighting levels helps establish a clear visual hierarchy, guiding the viewer's attention to the most significant elements (Arnheim, 2004).

Another important aspect of lighting design is the interaction between light and materials. Different materials reflect, absorb, or diffuse light in unique ways, affecting the overall lighting quality and atmosphere. For instance, glossy surfaces, such as polished stone or metal, tend to reflect light, creating sharp highlights and a sense of brightness. In contrast, matte surfaces, like wood or fabric, absorb light, producing a softer, more diffuse illumination. Architects carefully select materials based on their interaction with light, ensuring that the desired lighting effects are achieved. This consideration of materiality is crucial in creating visually rich and immersive environments (Ching, 2014).

In conclusion, lighting is an indispensable element in architectural design, shaping the visual and emotional experience of a space. Whether through the use of natural daylight or artificial lighting, architects use light to enhance spatial perception, establish visual hierarchy, and create mood. By understanding the principles of lighting design and its interaction with materials and human psychology, architects can create environments that are not only functional but also aesthetically pleasing and emotionally resonant. The thoughtful application of lighting ensures that spaces are visually compelling, comfortable, and aligned with their intended purpose (Zeisel, 2006).

5.4 The visual hierarchy

Visual hierarchy is a principle in design that dictates the order in which a viewer perceives and processes visual elements. It's based on the psychological and perceptual tendencies of the human brain, which prioritize certain stimuli over others to make sense of complex visual information. According to Arnheim (2004), our brains are wired to seek patterns and organize visual inputs in a way that highlights important features, helping us navigate and interpret our environment effectively.

In architectural design, visual hierarchy is essential for guiding occupants through a space and ensuring that key features and functions are immediately recognizable. Ching (2014) emphasizes that architects employ various techniques, such as contrast, scale, and positioning, to create a visual order that directs attention to critical areas like entrances, pathways, and focal points. For example, larger and more prominent elements, such as grand staircases or significant architectural features, naturally draw the eye, establishing a primary focal point. This use of scale and prominence helps users intuitively understand the layout and flow of a building.

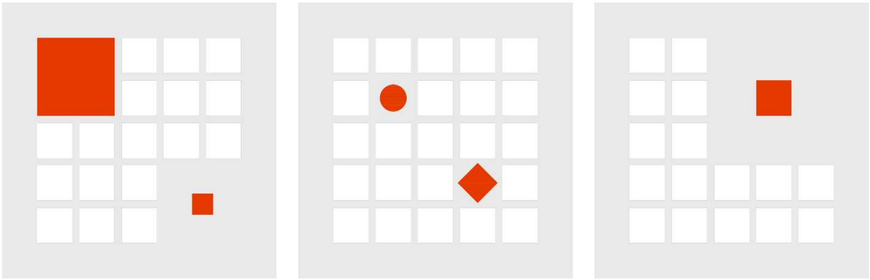


Figure 5.16 Hierarchy by shape, scale, and color – Author

Contrast is another vital tool in establishing visual hierarchy. By juxtaposing different colors, textures, and lighting, designers can make certain elements stand out against their surroundings. This principle is crucial in environments where clarity and quick comprehension are necessary, such as in public buildings and complex spaces (Ching, 2014). For instance, brightly colored signage against a neutral background ensures that important information is immediately noticeable and accessible.

Positioning also plays a crucial role in visual hierarchy. Elements placed at eye level or along natural lines of sight are more likely to be noticed and prioritized by viewers. This strategic placement is often used in museums and galleries, where the arrangement of exhibits guides visitors through a curated experience (Arnheim, 2004). Similarly, in architectural design, key functional areas are positioned to align with natural movement patterns, enhancing usability and comfort.

The principles of visual hierarchy extend beyond mere aesthetic considerations, impacting the functionality and experience of a space. By thoughtfully organizing visual elements, designers can create environments that are not only visually appealing but also intuitive and user-friendly. This approach ensures that important information and features are easily accessible, enhancing the overall experience for occupants (Ching, 2014).

Figure 5.17 Dresden Museum of Military – Archdaily

5.5 The Ames room illusion

While researching for this project, I came across the Ames room illusion. The Ames room is a well-known optical illusion that demonstrates how our brains interpret size and distance based on the shape of a room. The room is trapezoidal, with slanted walls and floors that appear to be rectangular from a specific viewpoint. As a result, objects and people inside appear to change size dramatically, depending on their position within the room.

This profoundly influenced my thinking about perception and space. The brain's natural tendency to misinterpret size and distance due to perspective—a concept we simplify in architecture as "perspective"—is actually rooted in complex scientific principles. This illusion occurs because the brain relies on visual cues to judge depth and scale, but can be easily tricked by unusual geometry. The Ames room demonstrates that the brain can be deceived into believing that two identical objects differ in size simply by altering spatial cues. This sparked my realization that architecture, like the Ames room, can manipulate perception in powerful ways. However, while scientific principles like perspective are clear-cut, architecture requires a more flexible approach.

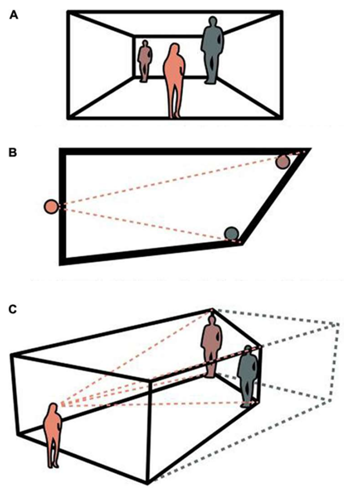


Figure 5.18 A sketch of the Ames Room - The embodiment of architectural experience (Wang, S., Sanches de Oliveira, G., Djebbara, Z., & Gramann, K., 2022).

(A) Displays what the perceiver encounters from a given point. Color-codes are used throughout the diagrams. (B) Displays a conceptual plan-drawing of an Ames Room. The red dashed lines represent the field of view of the perceiver. (C) Reveals the actual conditions under which an Ames room functions. The red dashed lines represent the field of view of the perceiver, while the blue dashed lines represent the outline of a rectangle, which the Ames room illusion suggests to exist from a specific angle (A).

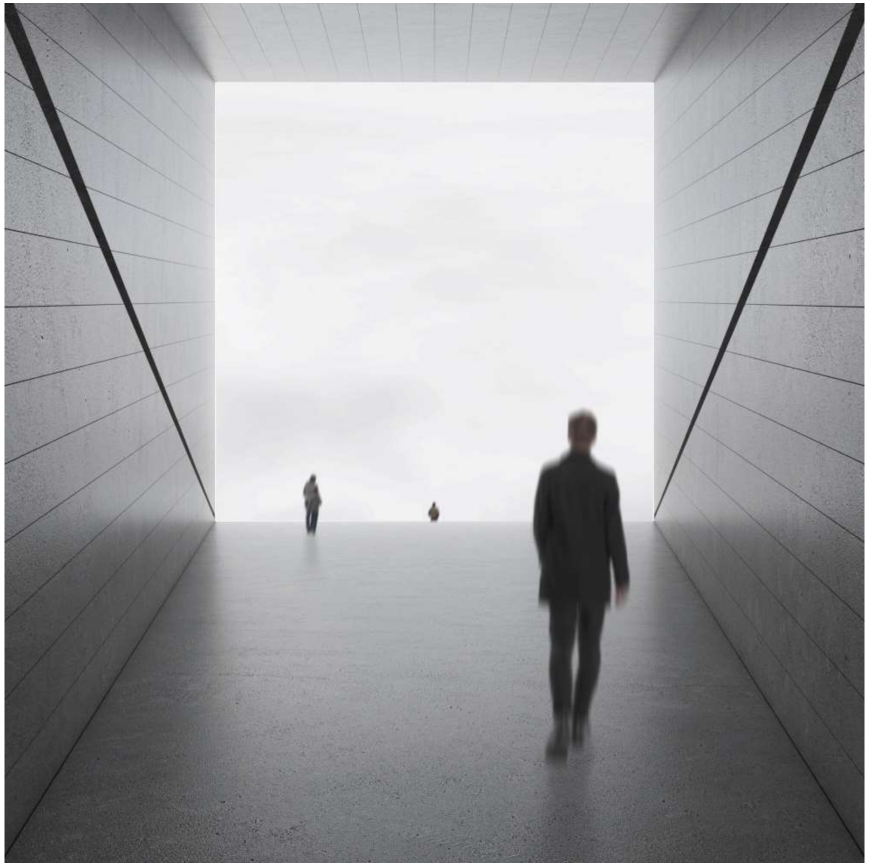
6. COMPETITION PROPOSAL: OUTBIDDING PERCEPTION

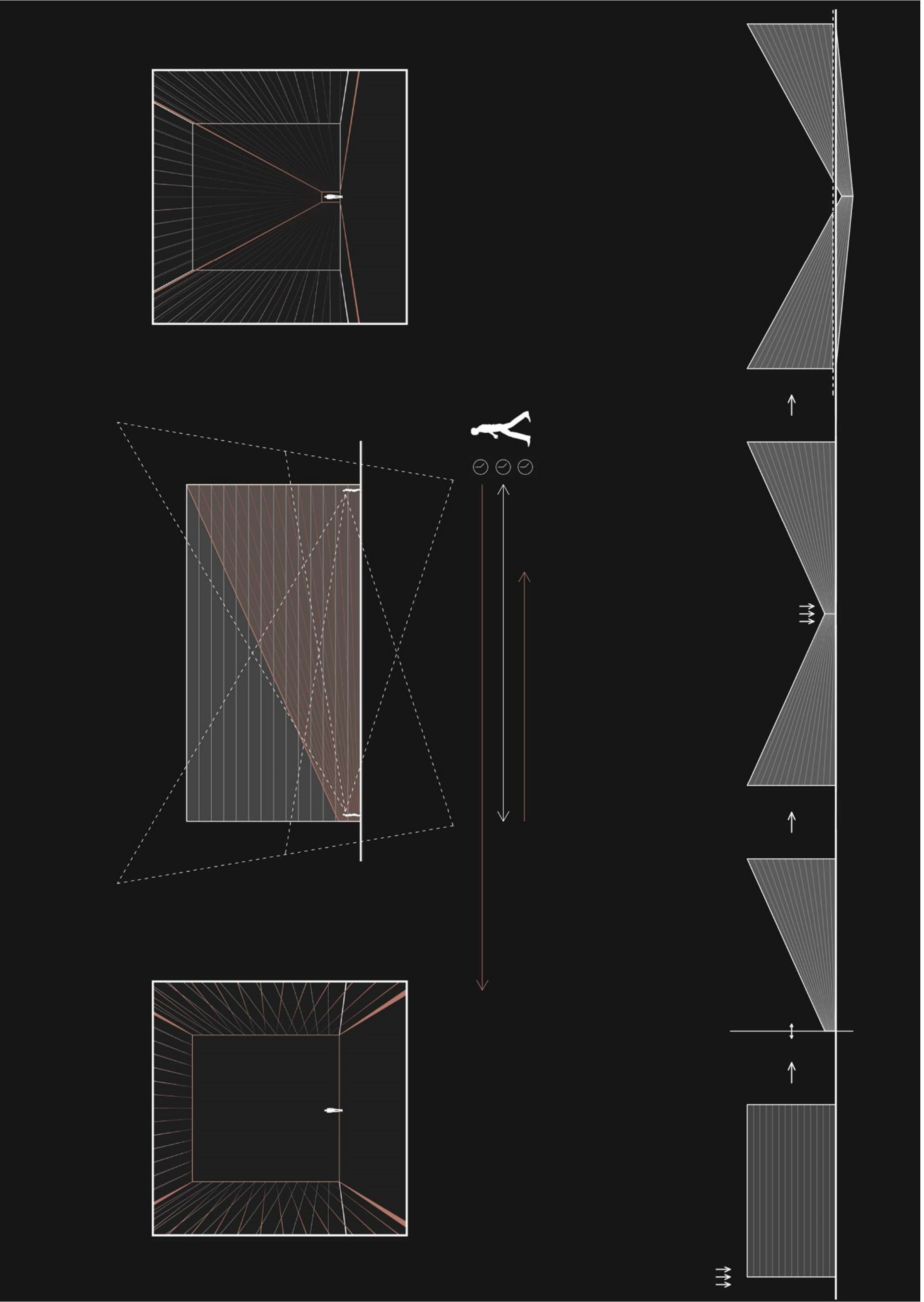
Figure 6.1 Museum of Emotions Competition Proposal, Exterior Perspective – Author

"Outbidding Perception" is a conceptual design that responds to the competition’s brief by focusing on the interplay between architecture and human emotions. The design consists of two spaces mirrored geometrically, one stimulating negative emotions and the other positive emotions, linked by an underground passage. The project is an architectural exploration of how space can manipulate **perception** and evoke contrasting emotional experiences through the distortion of perspective, light, and movement using the findings of the previous chapter scientific laws, particularly the phenomenon of size constancy and the Linear Perspective in human vision, the law of continuity in Gestalt principles, and the contrast in the visual hierarchy.

Figure 6.2 Museum of Emotions Competition Proposal – Author

Figure 6.4 Museum of Emotions Competition Proposal, Positive Space - Author





6.1 The Play of Perspective

The manipulation of perspective plays a central role in shaping the emotional journey within the museum. In the Negative Hall, the narrowing geometry creates a powerful spatial illusion that distorts the visitor's perception of distance. This intentional design taps into the brain's natural tendency to perceive closer objects as larger and farther objects as smallerleading to a perceptual miscalculation. As the walls close in and the floor slopes downward, the visitor's brain is tricked into interpreting the exit as being much farther away than it actually is. This subtle distortion heightens feelings of constriction, claustrophobia, and anxiety, as though the space is trapping the visitor in a psychological bind. The downward slope reinforces this sensation, giving the impression of sinking deeper into an unsettling, confined environment.

In contrast, the Positive Hall offers an opposing experience, yet follows the same principle of perspective manipulation. While this space is geometrically a mirror of the Negative Hall, it is perceived from the opposite direction, causing the space to expand outward. This outward expansion creates a sense of openness and clarity, but also results in a perceptual miscalculation, though in the opposite direction. Here, the space seems to stretch and pull the visitor toward a distant, unobstructed horizon. The visual flow is unimpeded, and the space, filled with light, evokes feelings of hope, freedom, and release. The shift in perspective from the contracting, oppressive Negative Hall to the expansive, liberating Positive Hall dramatically alters the visitor's emotional experience. By guiding the visitor's perception through these contrasting environments, the architecture itself becomes a vehicle for emotional transformation, using the innate tendencies of the human brain to craft an impactful journey from confinement to liberation.

Figure 6.3 Museum of Emotions Competition Proposal, Diagrams – Author

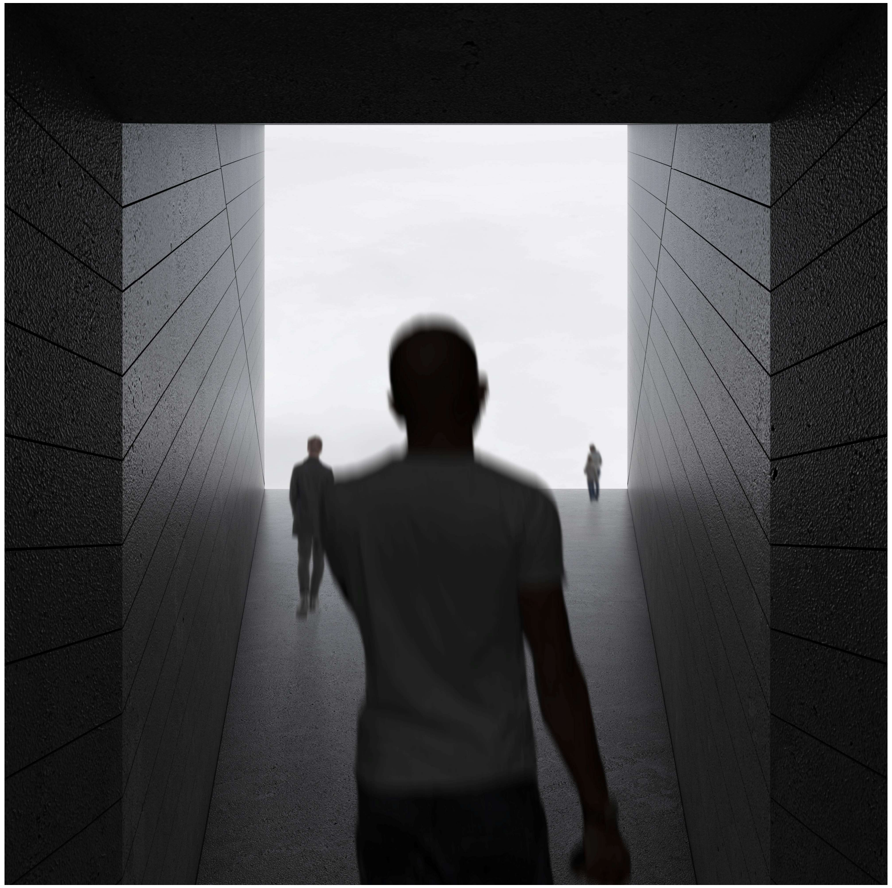


Figure 6.5 Museum of Emotions Competition Proposal, Underground Passage - Author

6.2 The Play of Lighting

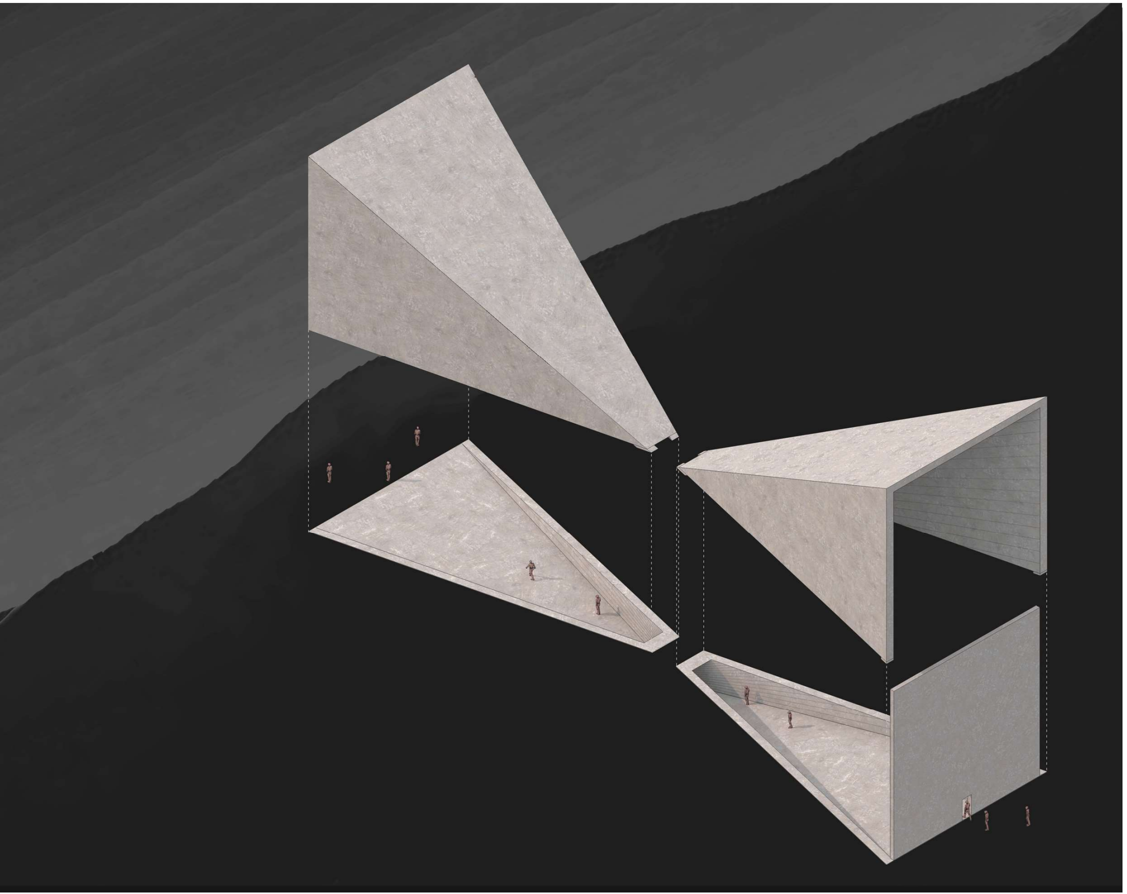
Lighting serves as a critical element in enhancing the emotional contrast between the two spaces, amplifying the distinct psychological atmospheres they evoke. In the Negative space, the absence of natural light creates an environment shrouded in darkness, which deepens the sense of confinement and unease. The hall's shadowy, closed-off nature strips away any visual comfort, leaving visitors engulfed in a space that feels isolating and oppressive. The lack of light reinforces the space's already constricting geometry, making the space feel even more claustrophobic and detached from the outside world.

Conversely, the positive space is bathed in natural light, a stark contrast to the oppressive gloom of the negative space. The large opening allows natural light to flood the space, establishing a strong visual and psychological connection to the outside world, creating an atmosphere of serenity, openness, and renewal. The presence of light enhances the sense of expansiveness, both physically and emotionally, as it evokes feelings of hope, clarity, and positivity. The lighting here becomes a symbol of liberation, guiding visitors out of darkness and into a space of openness and freedom. This manipulation of light reinforces the emotional journey between the two spaces, using illumination as a transformative element that deepens the contrast between confinement and release. The interplay of darkness and light, both literally and metaphorically, forms an integral part of the architectural narrative, guiding the visitor through an evolving sensory and emotional experience.

Figure 6.6 Museum of Emotions Competition Proposal, Negative Space - Author

Figure 6.7 Museum of Emotions Competition Proposal, Positive Space - Author

Figure 6.8 Museum of Emotions Competition Proposal, Exploded Axonometric – Author



6.3 The Play of Movement: Underground Transition

A key aspect of the design is the underground transition between the two halls. Movement through the pavilion is carefully orchestrated to deepen the emotional experience. The two halls, are connected by an underground passage. Visitors descend into the negative space, which reinforces a sensation of sinking or being pulled downward, symbolizing emotional weight or introspection.

The descent into enclosed space is recognized despite of the darkness, by the **linear ground-level opening** crossing the structure. This opening is a crucial design element, as it aligns with the ground plane, allowing visitors to clearly perceive their movement below the surface. From inside the space, looking through this opening, can only reveals the feet of people outside, reinforcing the feeling of being submerged or distanced from the world above.

In contrast, as visitors transition into the positive space, they experience an ascent, moving upwards toward openness, light, and emotional release. This upward movement symbolizes hope and emotional elevation, providing a powerful counterbalance to the previous descent. The interplay of descending into darkness and then ascending into light creates a dynamic emotional narrative within the architecture, guiding visitors through a journey of confinement to liberation.

Figure 6.9 Museum of Emotions Competition Proposal, Section - Author

6.4 The Cliffside Location

The pavilion's placement on a cliff introduces an element of surprise, deepening the emotional journey through its architectural design. Visitors enter through the negative space, which is intentionally set back from the cliff's edge, concealing the expansive view that lies beyond. As they move through the dark, narrow, and enclosed space, they are immersed in an atmosphere of confinement, completely unaware of the dramatic landscape that awaits them.

It is only upon exiting through the Positive Hall, which opens up near the cliff’s edge, that the breathtaking view of the sea is revealed. The breathtaking view of the sea and horizon, previously hidden from sight, unfolds in an instant. This sudden unveiling plays with the visitor's expectations, transforming the spatial experience from one of darkness and enclosure to one of light, openness, and release. The contrast between the two halls, combined with the cliffside setting, highlights the power of perspective in architecture. By keeping the view concealed until the final moment, the pavilion emphasizes the emotional shift from confinement to liberation, using the natural landscape as a vital part of the architectural narrative. This carefully orchestrated spatial reveal reinforces the pavilion’s role in shaping not only physical movement but also emotional and sensory perception.

Figure 6.10 Museum of Emotions Competition Proposal, Exterior Perspective – Author

6.5 Conclusion: A Continuing Exploration

Ultimately, my participation in the Museum of Emotions competition offered an opportunity to explore new dimensions of architecture—ones that transcend traditional considerations of aesthetics and functionality to engage with the emotional and psychological impacts of space. The process of designing for emotion presented significant challenges, from developing a design language capable of eliciting specific emotional responses to balancing empirical research with creative intuition. Additionally, I confronted the complexities inherent in working with emotions, which are deeply subjective and vary greatly from person to person. These challenges not only pushed me to rethink conventional architectural approaches but also deepened my understanding of how architecture can shape human experience on an emotional level.

The insights gained throughout this process have profoundly influenced my approach to emotional architecture. The questions that emerged—how to design spaces that evoke universally understood emotions, how to quantify or measure emotional impact, and how to integrate scientific principles without compromising creative expression—remain central to my ongoing research. These inquiries will continue to guide the development of my master's thesis, where I aim to further investigate the interplay between architecture and emotion. By building upon the foundation laid in this competition, I hope to contribute to a broader understanding of how architecture can meaningfully engage with the emotional and psychological dimensions of human experience.

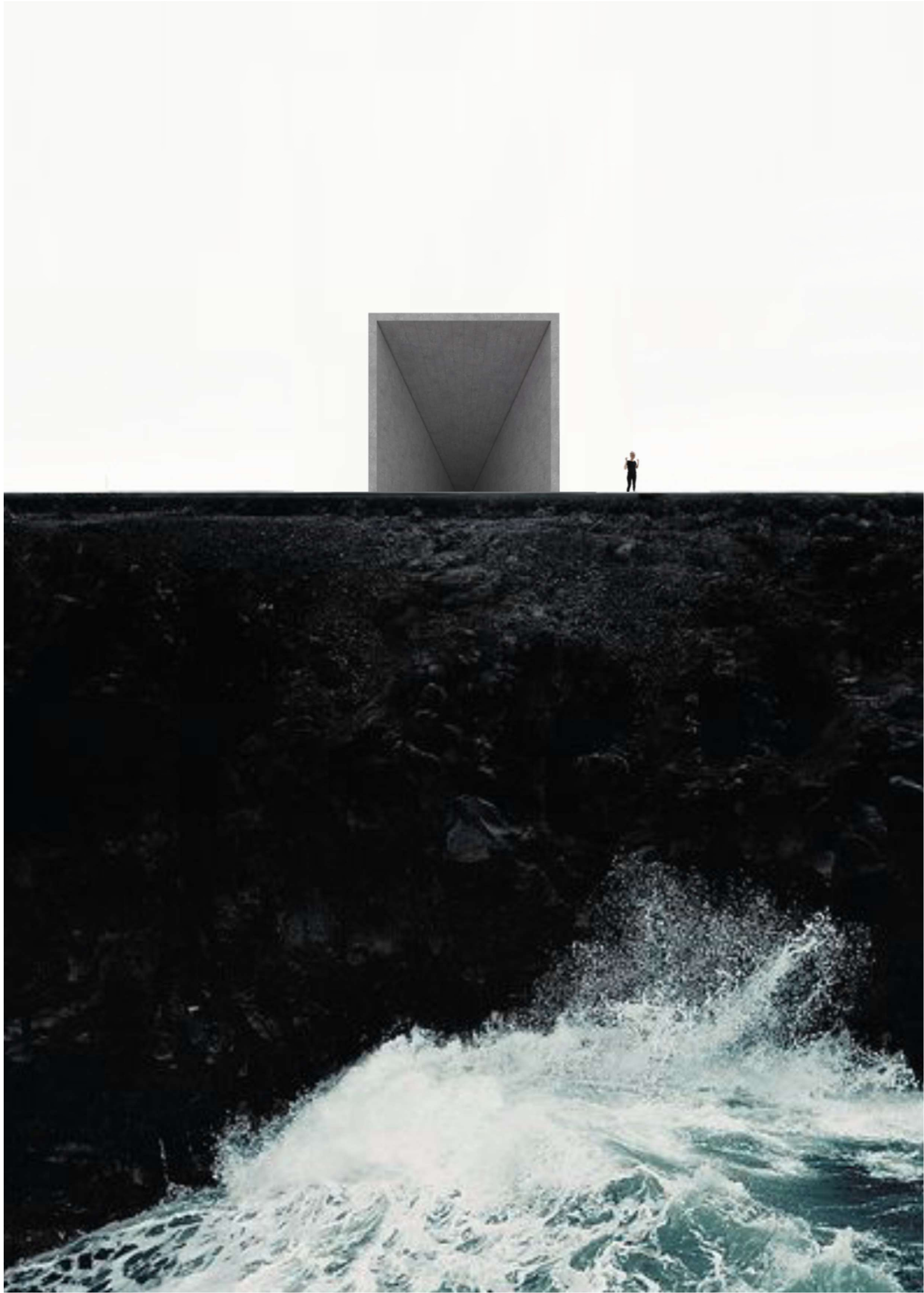


Figure 6.11 Museum of Emotions Competition Proposal, Exterior Perspective - Author

7. THE INTERSECTION OF NEUROSCIENCE AND ARCHITETURE

Neuroarchitecture is an emerging interdisciplinary field that explores how architectural design influences human emotions and behavior by examining the brain's responses to built environments .This field began to take shape in the early 21st century, building on principles from cognitive psychology and neuroscience. However, the roots of neuroarchitecture can be traced back to ancient practices like the Indian Vaastu Shastra and Chinese Feng Shui, which emphasized spatial harmony and aesthetic coherence .

In modern times, neuroarchitecture has gained traction as researchers have started to investigate the neural basis of human perception and interaction with architectural spaces. Pioneers in this field have highlighted the importance of elements such as natural light, color, and spatial layout in shaping our emotional and cognitive experiences. By integrating insights from neuroscience, architects can design spaces that not only meet functional needs but also promote mental well-being and positive social interactions.

In 2003, the Academy of Neuroscience for Architecture (ANFA) was established as the first organization dedicated to neuro-architecture, highlighting the importance of collaboration between architects and neuroscientists. This field blends neuroscience, environmental psychology, and architecture to explore how the brain responds to and interacts with built environments (Ruiz-Arellano, 2015). Researchers such as Karakas and Yildiz (2020) describe neuro-architecture as a framework for examining brain dynamics related to architectural spaces, while others, like Ahmed and Kamel (2021), emphasize its role in bridging scientific inquiry and architectural practice.

ANFA fosters studies on the impact of architectural environments on the neural system, contributing to design strategies aimed at improving human health and well-being (Eberhard, 2009; Azzazy et al., 2021). The field investigates diverse contexts, from enhancing productivity in office spaces to promoting patient recovery in hospitals and cultivating feelings of awe in sacred spaces (Dougherty and Arbib, 2013; Azzazy et al., 2021).

7.1 Neuroscientific Methods: FMRI and EEG in Neuroarchitecture

Recent advancements in brain imaging technologies have enabled neuroarchitecture to become a more sophisticated field. These methods fall into two categories: stationary and mobile paradigms. Stationary techniques, such as functional magnetic resonance imaging (fMRI), electroencephalography (EEG), and magnetoencephalography (MEG), require participants to remain still and are often used in controlled environments. They allow researchers to explore how people process architectural environments by presenting them with static images while they are seated or lying down. These methods provide valuable insights into the neural basis of perceiving architectural designs but are limited in ecological validity since they often involve two-dimensional images, not the full sensory experience of interacting with built environments.

On the other hand, mobile protocols allow participants to physically interact with real or virtual spaces, offering a more realistic assessment of how architecture impacts the brain. However, these approaches introduce challenges such as movement-related artifacts, reducing experimental control. Despite this, mobile brain imaging offers high ecological validity and the opportunity to study more dynamic aspects of human-environment interactions.

By combining both stationary and mobile imaging techniques, researchers can obtain a more comprehensive understanding of how architectural design influences brain activity and human experience

7.2 Neuroarchitecture Research Findings and Limitations

Most studies in neuroarchitecture have focused on stationary protocols, where participants view architectural stimuli while seated or lying down. These methods, like electroencephalography (EEG) and functional magnetic resonance imaging (fMRI), help researchers explore how people perceive architectural aesthetics. For example, research by Oppenheim et al. (2009, 2010) using EEG showed that buildings perceived as socially significant (such as government or religious structures) evoke stronger feelings of sublimity than those with lower status, like private or economic buildings. The hippocampus was identified as playing a key role in processing this architectural ranking.

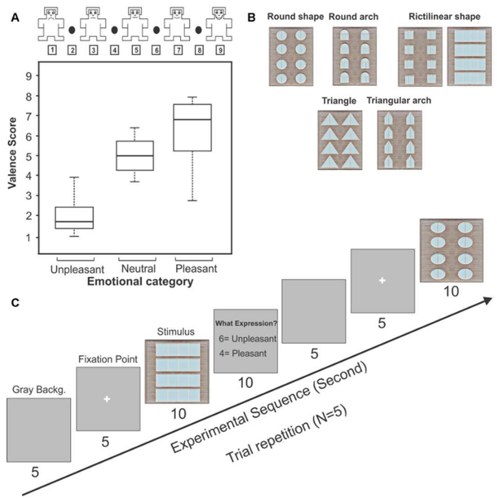
Another key finding is that participants tend to perceive curvilinear spaces as more aesthetically pleasing than rectilinear ones. Vartanian et al. (2013) discovered that curvilinear architectural interiors activated areas in the visual cortex, like the lingual and calcarine gyrus, more than rectilinear interiors. When participants made aesthetic judgments, curvilinear forms activated the anterior cingulate cortex. Further research by Vartanian et al. (2015) also indicated that spaces with higher ceilings and open layouts were rated as more beautiful and activated brain regions associated with spatial attention and perceived visual motion.

Cognitive expectations and expertise were found to influence aesthetic judgments as well. For instance, when the same image was labeled as coming from an art gallery rather than being computer-generated, participants rated it as more aesthetically pleasing. This was linked to activation in the medial orbitofrontal cortex (OFC) and prefrontal cortex (PFC) (Kirk et al., 2009b). Additionally, architects, compared to non-architects, exhibited greater activity in the bilateral medial OFC when judging the aesthetics of buildings. This demonstrates that expertise can affect brain responses related to reward in aesthetic evaluations.

While many studies have focused on aesthetics, others have explored the emotional impact of architectural design. For example, Naghibi Rad et al. (2019) used EEG to study how different window shapes influenced emotional responses. Shemesh et al. (2021) examined how geometric features like scale, proportion, and curvature affect emotional responses. Using physiological sensors such as EEG, Galvanic Skin Response (GSR), and eye-tracking. Other studies, such as those by Martínez-Soto et al. (2013), demonstrated that exposure to restorative environments (e.g., buildings integrated with vegetation) activated brain areas associated with attention and stress restoration, such as the middle frontal gyrus and the inferior temporal gyrus. Fich et al. (2014) found that participants in enclosed virtual spaces without windows experienced heightened stress responses compared to those in spaces with windows, as evidenced by prolonged increases in cortisol levels.

7.2.1 Encoding Pleasant and Unpleasant Expression of the Architectural Window Shapes: An ERP Study

Naghibi Rad et al. (2019) conducted a thorough investigation into the emotional and neural effects of different window shapes on human perception, using electroencephalography (EEG) as a central tool for understanding brain responses. The study explored how specific geometric configurations, including rectangular, square, circular, semi-circular, and triangular window designs, contribute to the emotional atmosphere of a space. The researchers operated under the hypothesis that architectural elements as detailed as window shapes play a critical role in shaping the overall environmental perception, which in turn affects the emotional well-being of the occupants. This hypothesis aligns with a growing body of evidence in environmental psychology and architecture, suggesting that the physical form of buildings can evoke specific emotional reactions.



The Self-Assessment Manikin (SAM) rating test and experimental design for electroencephalogram (EEG) recording. Panel (A) represents the SAM rating of geometric windows as a function of the emotional categories. The box shows the upper and lower quartiles, the bar inside the box represents the median, and error bars indicate the variability outside the upper and lower quartiles. Panel (B) represents the sample of geometric window shapes. Panel (C) represents the experimental procedure for EEG recording setup.

Figure 7.1 The Self-Assessment Manikin (SAM) - (Naghibi Rad, P., Shahroudi, A. A., Shabani, H., Ajami, S., & Lashgari, R., 2019).

The experimental setup involved exposing participants to visual stimuli of different window shapes in a controlled setting. EEG was employed to monitor brain activity, particularly focusing on the asymmetry of hemispheric activation, a key indicator of emotional processing. Previous research has demonstrated that emotional responses can often be lateralized in the brain, with positive emotions typically linked to greater left hemisphere activity, while negative emotions are often associated with the right hemisphere (Davidson, 1992). In this study, the results showed that participants found rectangular, square, circular, and semi-circular windows to be more aesthetically pleasing, as evidenced by increased activation in the left hemisphere of the brain. This finding reinforces existing research on how positive emotional states correspond to left-hemispheric brain activity, thereby suggesting that these particular window shapes can evoke positive emotional responses in occupants.

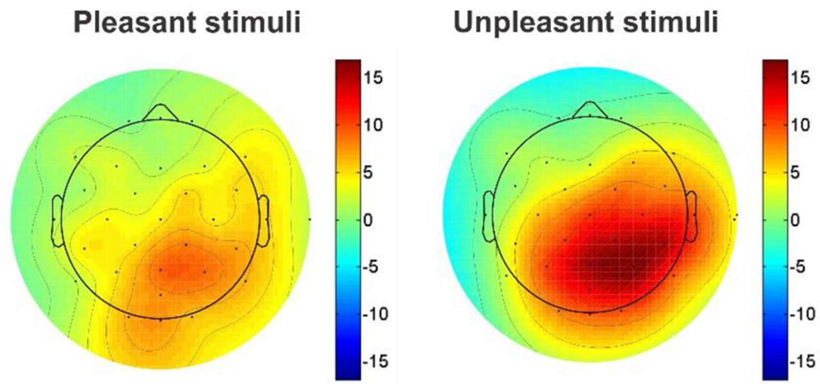


Figure 7.2 Topographic maps of comparison EEG response activity to the pleasant and unpleasant window shapes (Naghibi Rad, P., Shahroudi, A. A., Shabani, H., Ajami, S., & Lashgari, R., 2019).

On the other hand, triangular windows elicited a markedly different response. The EEG data showed heightened activation in the right hemisphere, which is commonly associated with negative emotions, stress, and discomfort (Davidson, 1992). This hemispheric asymmetry demonstrates that window geometry can influence emotional responses in diverse ways, depending on the shape. The triangular windows, which are less common and perhaps perceived as more angular or harsh, activated brain regions linked to negative emotional processing, highlighting the brain's sensitivity to even minor architectural details.

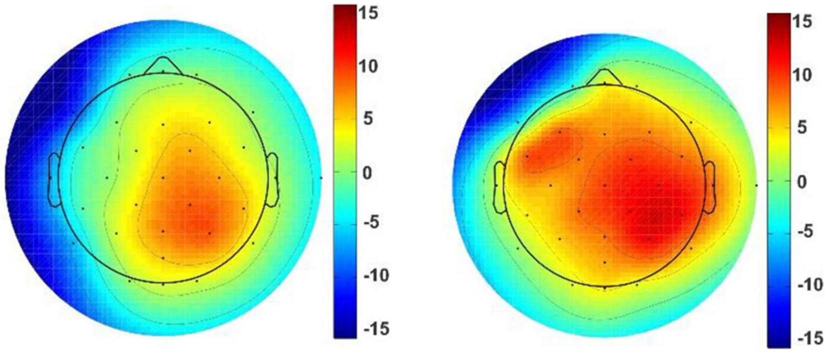


Figure 7.3 Topographic Map Of The Unpleasant Stimuli - (Naghibi Rad, P., Shahroudi, A. A., Shabani, H., Ajami, S., & Lashgari, R., 2019).

Topographic maps reveal ERP voltage(V) for unpleasant stimuli with triangle(left picture)and triangular arch(right picture) shapes at the p4.Thecolor maps are the averaged amplitude of all unpleasant responses for triangle and triangular arch pictures.

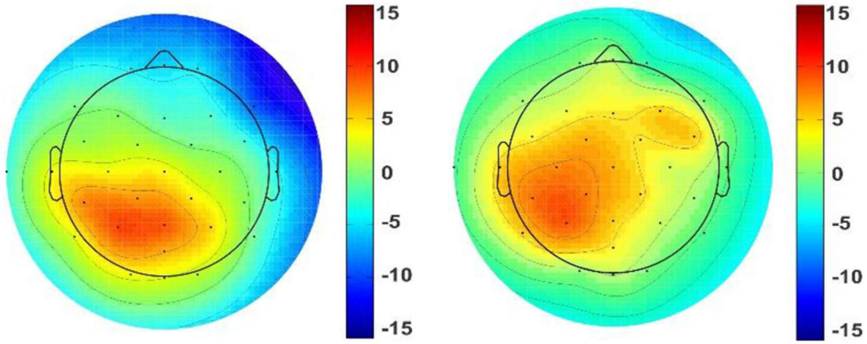


Figure 7.4 Topographic Map Of The Pleasant Stimuli - (Naghibi Rad, P., Shahroudi, A. A., Shabani, H., Ajami, S., & Lashgari, R., 2019).

Topographic maps reveal ERP voltage (V) for some of the pleasant stimuli such as circle (left picture) and semi-circular arch (right picture) shapes. The color maps are the averaged amplitude of all pleasant responses for circle and semi-circular arch pictures.

Moreover, Naghibi Rad et al.'s (2019) research not only measured neural activity but also included subjective self-reports from participants. These self-reports allowed the researchers to gather conscious emotional feedback, which, when combined with EEG data, provided a more comprehensive understanding of how window shapes impact emotional and cognitive states. This dual approach of combining objective neuroimaging data with subjective emotional feedback represents a significant methodological strength of the study. It emphasizes how design features such as window shapes are not only aesthetically significant but also function as powerful stimuli that can affect mood, cognition, and overall experience within a space.

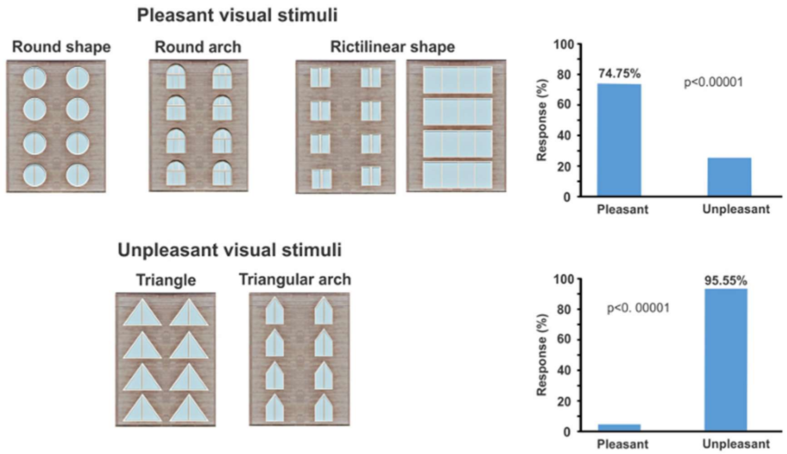


Figure 7.5 Pleasant and Unpleasant Stimuli Based on Participants' Viewpoint - (Naghibi Rad, P., Shahroudi, A. A., Shabani, H., Ajami, S., & Lashgari, R., 2019).

Participants were asked to identify pleasant and unpleasant stimuli by the key press (button 4 or 6). The right plot shows the percentage of responses for both pleasant and unpleasant window categories

The broader implications of this study are particularly relevant to the field of architecture and environmental psychology. The findings suggest that what might initially seem like a minor architectural detail—the shape of windows—can, in fact, have profound psychological and physiological effects on those who inhabit the space. By selecting window shapes that are more likely to be perceived as pleasing or calming, architects and designers can potentially enhance the emotional well-being and comfort of individuals in residential, commercial, or public spaces. This insight encourages a more nuanced approach to design, where the emotional impacts of architectural elements are carefully considered alongside functionality and aesthetics.

In summary, the study conducted by Naghibi Rad et al. (2019) sheds light on the complex relationship between window shapes and emotional responses, demonstrating that rectangular, square, circular, and semi-circular windows tend to activate the brain's left hemisphere, which is associated with positive affect. In contrast, triangular windows are linked to right-hemispheric activation, often corresponding to negative emotions. These findings underscore the importance of integrating neuroscientific insights into architectural design to create spaces that promote positive emotional experiences and contribute to the well-being of occupants. By acknowledging the emotional and psychological significance of architectural features, this research contributes to a deeper understanding of how design can shape human experience in profound ways.

7.2.2 The emotional influence of different geometries in virtual spaces: A neurocognitive examination

Shemesh et al. (2021) conducted a comprehensive neurocognitive investigation aimed at exploring the emotional and cognitive responses triggered by different geometric configurations within virtual architectural spaces. Their research utilized a sophisticated array of physiological measurement tools, including electroencephalography (EEG), Galvanic Skin Response (GSR), and eye-tracking (ET), to gather in-depth data on participants' emotional and cognitive reactions to varied architectural geometries. A total of 112 participants were exposed to a range of controlled virtual spaces, each designed with specific geometric manipulations—such as protrusion, curvature, scale, and proportion—carefully integrated into the virtual environment to test the study's hypotheses.

The researchers' primary hypothesis was that the manipulation of geometric features would substantially influence emotional responses. This hypothesis is well-founded in the existing body of knowledge that spatial geometry is a fundamental element in shaping human experience and perception within architectural contexts. The EEG data provided critical insights into the neural correlates associated with emotional reactions to various geometries, identifying distinct patterns of brain activity tied to different spatial configurations. For instance, large symmetrical spaces were found to elicit more positive emotional states, as evidenced by increased alpha wave activity, which is typically associated with relaxation and a sense of well-being. On the other hand, extreme geometric alterations, such as overly narrow or excessively wide spaces, prompted feelings of unease and anxiety, as indicated by heightened beta wave activity, which correlates with stress and emotional distress.

In conjunction with EEG data, the GSR measurements offered valuable information on participants' autonomic nervous system responses, providing a direct physiological marker of emotional arousal. The findings demonstrated that participants exhibited lower levels of skin conductance when exposed to proportionate and symmetrical spaces, suggesting that these environments promoted feelings of calmness and comfort. In contrast, irregular and disproportionate spaces led to elevated skin conductance levels, indicative of heightened emotional arousal and discomfort. These results were further validated by eye-tracking data, which revealed patterns of visual attention. Participants spent more time visually engaged in symmetrical and aesthetically harmonious environments, displaying smoother gaze patterns, while their eye movements became more erratic and fixation durations shortened in response to geometrically challenging or disorienting spaces.

Moreover, the study provided an intriguing comparison between designers and non-designers, highlighting significant differences in emotional reactivity to geometric variations. Non-designers, who lack professional training and aesthetic expertise, exhibited stronger emotional responses to changes in spatial geometry. This finding suggests that individuals with architectural or design expertise may experience a form of emotional buffering, potentially due to their ability to process spatial characteristics more analytically rather than emotionally. The more intense emotional reactions observed in non-designers could imply a more visceral, intuitive engagement with space in the absence of formal design conditioning.

Shemesh et al.'s (2021) research emphasizes the crucial role that geometric design plays in influencing emotional well-being within architectural spaces. Their study highlights the importance for architects to carefully consider geometric elements when designing environments aimed at fostering positive emotional experiences. By merging neurocognitive methodologies with architectural design theories, the study offers a compelling framework for understanding the emotional implications of spatial geometry. This interdisciplinary approach not only advances the field of environmental psychology but also provides actionable insights for the creation of built environments that promote psychological health and emotional well-being. Through this work, the researchers underscore the potential for applying scientific methodologies to the practice of architectural design, ensuring that spaces are not only functional but also emotionally nurturing.

7.2.3 Neural responses to restorative environments: an eye tracking and fMRI study

Martínez-Soto et al. (2013) conducted an extensive study to examine the neurocognitive effects of restorative environments, particularly those enriched with natural elements like vegetation. The research employed advanced neuroimaging techniques, including functional magnetic resonance imaging (fMRI) and eye-tracking technology, to delve into how exposure to urban spaces with varying levels of greenery impacts brain activity and emotional states. Participants in the study were exposed to a series of images depicting different urban environments, ranging from highly vegetated areas to those with minimal natural elements, offering a spectrum of greenery.

The fMRI results revealed significant activation in two key brain regions: the middle frontal gyrus and the inferior temporal gyrus. Activation of the middle frontal gyrus, a brain area associated with attentional regulation, executive function, and higher-order cognitive processes, suggests that natural environments not only capture attention but also support cognitive functions essential for mental restoration and stress alleviation.

The inferior temporal gyrus, which plays a critical role in visual processing and memory, was also highly engaged, reinforcing the notion that green spaces facilitate visual attention and memory processes. These findings strongly support the Attention Restoration Theory (ART), which posits that natural environments provide a restorative experience by engaging involuntary attention, allowing directed attention to recover from mental fatigue.

In addition to the neuroimaging data, the eye-tracking component of the study provided further insight into participants' visual engagement with the natural elements present in the images. The data indicated that participants consistently fixated on vegetative components within the urban scenes, demonstrating a strong visual preference for green spaces. This visual focus on greenery was directly linked to positive emotional responses, as participants reported feelings of calm and reduced stress levels. The physiological evidence gathered through eye-tracking, which aligned with the fMRI findings, confirmed that natural elements in urban spaces foster positive emotional states, promoting psychological well-being.

This study highlights the intricate relationship between environmental design and brain function, emphasizing that the integration of natural elements in architectural and urban spaces can significantly enhance mental health. By showing that green spaces activate brain regions related to attention and emotional regulation, Martínez-Soto et al. provide robust evidence in favor of biophilic design principles. Biophilic design advocates for the incorporation of natural elements, such as vegetation, into the built environment, aiming to create spaces that not only satisfy aesthetic demands but also promote human health and well-being.

The practical implications of these findings are profound for architects, urban planners, and policymakers. The study suggests that urban environments enriched with greenery can promote cognitive functioning, reduce stress, and contribute to overall well-being. This is particularly relevant in densely populated urban settings, where residents are frequently exposed to environmental stressors such as noise, pollution, and overcrowding. Incorporating green spaces into urban designs can create restorative environments, offering a vital counterbalance to these stressors and enhancing the quality of life for urban residents.

In conclusion, the research conducted by Martínez-Soto et al. (2013) offers an in-depth understanding of the neurocognitive benefits provided by restorative environments. By highlighting the crucial role that natural elements play in fostering emotional regulation and cognitive well-being, the study advocates for a more holistic approach to architectural design and urban planning. This approach underscores the importance of integrating nature into urban spaces to promote sustainable, health-enhancing environments that support both individual and community well-being. The findings offer compelling evidence for the necessity of biophilic urban design in shaping future cities that prioritize mental health, emotional balance, and overall sustainability

7.2.4 Neuroarchitecture Research Limitations

These studies illustrate that architecture not only affects how we perceive beauty but also significantly influences our emotional and physiological states. However, limitations remain, particularly in balancing ecological validity and experimental control, which calls for further research using both stationary and mobile methods to deepen our understanding of the complex relationship between architecture, emotion, and brain activity.

Based on the above, two main problems in current neuroarchitecture research are identified:

- Limited Focus on Aesthetic Dimension: Much of the research in neuroarchitecture tends to concentrate primarily on the aesthetic aspects of architectural experience, neglecting other important dimensions such as functionality, usability, and the overall human experience within a space.
- Practical Limitations of Experimental Tools: Traditional brain-imaging methods often require participants to remain stationary, which limits naturalistic interaction with the architectural environment. This constraint can hinder the ecological validity of the research, as it does not accurately reflect real-world interactions with architectural spaces.

These limitations highlight the need for more comprehensive approaches and advanced methodologies to better understand the full impact of architectural design on human brain function and behavior.

8. MOBILE BRAIN/BODY IMAGING (MOBI) AND ITS IMPLICATIONS

Mobile Brain/Body Imaging (MoBI) represents a novel multimethod approach in neuroscience that allows researchers to investigate human cognition and behavior in naturalistic settings, where participants can actively move and interact with their environment. This method provides a more ecologically valid way of studying the brain and body dynamics compared to traditional, stationary experiments. By combining brain imaging techniques with motion capture and other sensory data, MoBI offers the possibility of capturing the complex relationship between human perception, action, and the built environment (Jungnickel et al., 2019; Parada and Rossi, 2021).

8.1 Defining MoBI and Its Core Objectives

MoBI is defined as a brain imaging technique that records neural activity while participants engage in free movement and interaction with their surroundings. This approach integrates multiple data streams, including brain signals (typically through EEG), motor behavior, and environmental factors, which are then analyzed to dissociate neural processes from non-brain activities (Gramann et al., 2011; Makeig et al., 2009). One of the primary goals of MoBI is to model and understand cognition during unrestricted, exploratory action within an environment, thereby aligning closely with principles of ecological psychology, which emphasize the importance of studying human behavior in real-world contexts (Gramann et al., 2014). This methodology is particularly relevant for neuro-architectural research, as it enables an exploration of how individuals interact with and experience architectural spaces in real time.

A key feature of MoBI is its ability to capture embodied cognitive processes—those that arise from the interaction between the mind, body, and environment. This approach emphasizes the need for small, lightweight equipment that allows participants to move freely, enabling researchers to investigate how bodily movement and spatial exploration influence cognitive and emotional responses (Jungnickel et al., 2019). The synchronization of brain and motor dynamics is essential for understanding the bidirectional relationship between behavior and neural activity, especially in complex, real-world settings such as architectural environments.

8.2 MoBI's Relevance in Neuro-Architecture

Recent studies have demonstrated the potential of MoBI to enhance the ecological validity of neuro-architectural research by allowing participants to actively explore architectural spaces. For instance, Banaei et al. (2017) investigated how different interior forms in architecture influenced brain activity and affective experiences. Participants walked through architectural spaces designed with varied forms, and the study found that the curvature of interior forms activated different brain regions, including the anterior cingulate cortex (ACC) and posterior cingulate cortex, suggesting that both the spatial layout and active exploration shape the brain's response to architecture. This research highlights MoBI’s capacity to provide a neuroscientific basis for understanding how specific architectural features, such as geometry and perspective, impact human experience.

In another study, Djebbara et al. (2019, 2021) examined how transitions through doors of varying widths influenced brain dynamics and emotional experiences. The study utilized virtual reality (VR) to simulate architectural spaces and recorded participants' brain activity as they navigated through doors of different sizes. The results indicated that brain activity in visual and motor areas was influenced by the architectural affordances—features of the environment that facilitate or constrain movement. Even when no movement was required, participants' brains responded to the affordances present in the space, supporting the idea that the potential for action shapes our perception of architecture (Djebbara et al., 2019). These findings underscore the importance of MoBI for studying how architecture impacts cognitive and emotional processes, offering insights into how design elements can influence human behavior in built environments.

8.3 MoBI in Virtual and Augmented Reality for Controlled Experiments

While MoBI excels in providing ecological validity by allowing for natural movement, this comes at the cost of reduced experimental control. To address this challenge, researchers have integrated virtual reality (VR) and augmented reality (AR) with MoBI setups. These technologies enable controlled presentation of stimuli while maintaining the immersive, interactive nature of real-world environments (Jungnickel et al., 2019). For example, in the Djebbara et al. (2019) study, the use of VR allowed for precise manipulation of door widths and transitions while still enabling participants to move naturally within the virtual environment. By combining MoBI with VR or AR, researchers can systematically manipulate architectural variables, such as room layout, lighting, or door affordances, and measure their effects on brain and body dynamics.

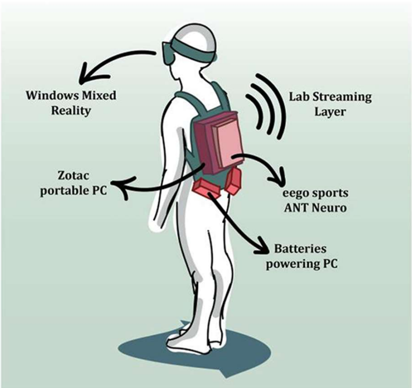


Figure 8.1 MoBI setup using mobile EEG hardware combined with virtual reality and motion capture through the VR tracking system - (Djebbara, Z., et al., 2021).

8.4 Implications and Future Directions

MoBI offers a transformative approach to studying how people perceive, navigate, and emotionally respond to architectural spaces. By enabling real-time exploration and interaction with the built environment, MoBI can uncover the neural mechanisms underlying our experiences of architecture, revealing how design elements such as form, scale, and affordance influence perception and behavior. Furthermore, MoBI allows for the integration of multiple sensory modalities—visual, auditory, and tactile—thereby expanding the scope of architectural research to include a broader range of sensory experiences.

As this field evolves, it is important for researchers to adopt a cautious and incremental approach to the design of MoBI experiments, gradually introducing complexity to ensure that results remain replicable and valid (Parada, 2018; King and Parada, 2021). By first conducting experiments in highly controlled environments and then gradually increasing ecological complexity, researchers can better understand the interactions between brain dynamics, motor behavior, and environmental factors. This systematic approach will help to refine the methodology and further establish MoBI as a powerful tool for neuro-architectural research.

In summary, MoBI represents a significant advancement in the study of human experience within architectural spaces, offering a unique combination of ecological validity and experimental control. Through continued exploration and technological refinement, MoBI holds the potential to revolutionize our understanding of the relationship between architecture, perception, and emotion.

9. ATMOSPHERE IN ARCHITECTURE AND NEUROSCIENTIFIC METHODS

9.1 Lived Body and Living Body

In the context of atmospheric dynamics, a central point of agreement among scholars is that “there is no such thing as an unfelt atmosphere” (Osler and Szanto 2022). When we discuss the "body," we refer to its holistic complexity. This includes the living body—the biological, sensory-responsive organism—and the lived body—the subjective, experiential dimension shaped by personal life experiences (Shusterman 2010). These two aspects, though conceptually distinct, are part of one integrated body that is both physiological and lived, as philosopher (Shaun Gallagher explains 1986). This distinction plays a significant role in how we perceive atmospheres in architecture.

Traditionally, the study of atmospheres has been grounded in phenomenology, focusing on the lived body, or how individuals perceive and experience space from a first-person perspective. However, in recent years, research has begun to include the living body, viewed from a third-person perspective, using empirical methods such as neuroscience (Mallgrave and Gepshtein 2021). Neuroscience, which studies human experience based on nervous system activity, provides a biological lens through which to examine atmospheric experiences, emphasizing how the brain and autonomic nervous system process emotional responses to architectural spaces (Gallese and Cuccio 2015).

Given that atmospheres affect us on conscious, preconscious, and nonconscious levels (Tamietto and de Gelder 2010), it is crucial to investigate the interaction between the living and lived body. This combined approach allows us to better understand how architecture can evoke emotional responses through both physiological and experiential means (Jelić et al. 2016). The intersection of architectural design, biology, and phenomenology, as articulated by scholars such as Colombetti (2017) and Arbib (2021), transforms atmosphere into a measurable entity, accessible through experimental protocols aimed at understanding our emotional responses to built environments (Canepa 2022a).

This dual perspective—of the living and lived body—sets the stage for investigating architectural atmospheres and their emotional impacts. By exploring how physiological reactions and subjective experiences interact, we gain deeper insights into how architectural atmospheres prime emotional experiences.

9.2 Resonance and Attunement in Atmospheric Experience

Atmospheric experiences can be understood as states of emotional **resonance** and **attunement** between individuals and their architecturally organized surroundings. Resonance occurs when an individual is emotionally touched by their environment, while attunement refers to how deeply they become affectively involved. Importantly, one can perceive an atmosphere without fully aligning with it—there’s a distinction between recognizing the emotional tone of a space (resonance) and personally engaging with it on a deeper level (attunement). As Osler and Szanto (2022) explain, just because we perceive a party’s joyful atmosphere does not mean we must feel joy ourselves; we might even misinterpret the atmosphere entirely.

Resonance taps into our natural sensitivity to external stimuli and is triggered by the immediate impressions formed when we enter a space. These first impressions, shaped by atmospheric affordances like light, sound, and materials, provide meaningful information about the environment in a matter of moments (Griffero 2020b; Zumthor 2006). Research has shown that first impressions arise almost instantaneously, enabling rapid emotional processing and engagement with the world around us (Bar, Neta, and Linz 2006; Djebbara et al. 2019). These impressions manifest through four primary feedback modalities: emotional responses, physiological expressions, behavioral tendencies, and consciously felt feelings.

Through resonance, we experience the atmosphere via nonconscious bodily reactions—such as a quickened heartbeat or a change in posture—and through conscious emotional experiences, like feeling anxious or calm. This process allows individuals to sense an atmosphere's presence and to feel either attuned or detached, depending on their personal emotional engagement. For instance, a person may sense their heart pounding (a bodily response) without consciously recognizing they feel nervous (a feeling).

Attunement, on the other hand, involves the conscious appraisal of an atmosphere and how its emotional content relates to an individual's personal perception. During this process, people attribute emotional qualities to the space—evaluating whether it feels pleasant, overwhelming, or serene. Attunement links our emotional resonance with deeper reflections on the significance of the environment and our affective connection to it. This cognitive-emotional evaluation results in more intentional judgments of the space’s atmosphere, shaped by personal moods, motivations, and expectations.

Using a combination of neuroscientific methods, psychology, and phenomenology, scholars have begun to explore how nonconscious body-brain responses correlate with conscious emotional perceptions of space (Kim and Kim 2022). This multi-perspective approach allows for the assessment of architectural atmospheres by examining both conscious feelings and nonconscious emotions, offering insights into how architecture affects human experience. It is through this lens that resonance and attunement can be evaluated, providing a foundation for understanding how architecture emotionally influences us.

Research indicates that first impressions occur at an extraordinary speed, which is a significant aspect of our interaction with architecture (Bar, Neta, and Linz 2006; Djebbara et al. 2019). These impressions manifest through four key modalities:

- A: Emotions – internal somatic feedback, nonconscious but sometimes consciously recognized.
- B: Expressions – outward physiological and proprioceptive feedback, primarily nonconscious.
- C: Action tendencies – behavioral feedback, largely nonconscious.
- D: Feelings – conscious cognitive feedback of the emotional experience.

These modalities are interconnected, as emotions, expressions, and actions serve as bodily correlates of feelings, influencing each other. For example, one might sense their heart racing (A), facial expressions changing (B), or an urge to exit (C), while consciously feeling nervous (D). Through the process of resonance, which involves bodily reactions and possibly conscious awareness of the emotional state, we perceive the atmosphere of a space. This perception is centered on the individual's experience, making the perceiving subject the primary focus.

9.3 First-person-perspective-based Research and Third-person-perspective-based research

In architecture, the first-person-perspective-based research models offer valuable insight into how individuals consciously perceive their emotional states within architectural environments. This approach focuses on analyzing emotions based on personal, lived experiences, emphasizing that all subjective phenomena are inherently linked to an individual's point of view, as outlined by Nagel (1974). Emotional states, as Barrett et al. (2007) suggest, can be scientifically relevant even when simplified or not fully articulated, as individuals metabolize and express their spatial experiences through various modalities (De Matteis et al., 2019).

Articulating these experiences often involves engaging with bodily sensations, which can be categorized into three stages: during real-time introspection, after the experience, or beforehand, to compare the emotional shift. Interoception—our awareness of internal body signals—can enhance the accuracy of our environmental perception (Murphy Paul, 2021), though it's not definitively established if internal body awareness influences external perception (Baiano et al., 2021).

Measuring emotional responses traditionally focuses on three factors: arousal, valence, and dominance. These are often assessed using techniques such as Likert-type scales or the Self-Assessment Manikin (SAM) (Bradley and Lang, 1994). These methods offer insights into the intensity, pleasantness, and control of emotional experiences, yet they come with limitations such as cognitive biases and the complexity of introspection. Despite these challenges, first-person reports are considered crucial, as only the individuals experiencing emotional resonance can accurately articulate it.

To further complement subjective measures, third-person-perspective-based models focus on non-conscious emotional stimuli and their effects on behavior and neurophysiology (Tamietto and de Gelder, 2010). By studying unconscious or marginally conscious emotional reactions to architectural spaces, this model evaluates emotional experiences on three levels: behavioral outputs, physiological responses, and neural activity. Tools such as electrodermal activity (EDA), heart rate (HR), and neuroimaging techniques like EEG and fMRI provide deeper insights into how architecture impacts us beyond conscious awareness (Bower et al., 2019).

Together, these first- and third-person approaches highlight the multi-faceted nature of emotional responses to architectural atmospheres, stressing the importance of integrating both subjective reports and neurophysiological markers to achieve a comprehensive understanding of how space shapes our emotional experiences.

In conclusion, while first-person observations are limited to consciously perceived emotional states (namely feeling), third-person observations evaluate nonconscious and preconscious emotions on three different levels:

on the experience level, studying behavioral outputs (action tendencies or interferences on task performance) and corporeal expressions; on the body level, recording physiological activities, and on the brain level, monitoring neural functioning.

9.4 Methods and Techniques

Researchers employ several methods and techniques to assess emotional responses to architecture. Action tendencies—the behaviors influenced by emotions—are often measured using posture sensors and movement detection (Mallgrave & Gepshtein, 2021). Another method involves examining the effects on task performance, analyzing how emotional stimuli impact cognitive functions such as reaction time or attention engagement (Tamietto & de Gelder, 2010). Expressive responses like facial expressions and vocal acoustics provide additional insight into emotional states, while physiological activity is assessed through heart rate, skin conductance, and hormonal secretions (Jelić et al., 2016). Finally, neural activity is explored using techniques such as electroencephalography (EEG) and functional magnetic resonance imaging (fMRI), which offer a more direct look at brain function in relation to emotional stimuli (Gallese & Cuccio, 2015).

These tools and techniques provide a multidimensional approach to understanding how nonconscious emotions impact behavior and decision-making within architectural environments (Canepa, 2022a).

9.5 Importance of Multi-Perspective Research and Methodological Challenges

To gain a comprehensive understanding of how architecture shapes emotional experiences, it is essential to use both self-reports and physiological measures (Kim & Kim, 2022). Self-reports allow individuals to articulate their conscious feelings, while physiological measures, such as heart rate or neural scans, capture nonconscious emotional responses (Bradley & Lang, 1994). Often, these two methods reveal discrepancies—for instance, a person may report feeling no emotion, but physiological data might indicate signs of stress or excitement (Tamietto & de Gelder, 2010).

By combining different markers—psychological tests, behavioral observations, physiological measurements, and brain scans—researchers can assess emotional resonance in architectural settings more accurately (Jelić et al., 2016). This multi-perspective approach helps ensure that the methods chosen capture the full scope of emotional responses and their influence on behavior and perception (Canepa, 2022a).

One significant methodological challenge lies in ensuring consistency between measures. When using neuroscientific techniques, it is critical to determine if nonconscious physiological and neural responses align with what individuals consciously report about their emotions (Tamietto & de Gelder, 2010). Often, subjective reports serve as a baseline for comparison with objective, quantitative data obtained from neuroscientific tools like EEG or EDA (Bradley & Lang, 1994).

Maintaining alignment between subjective indicators and physiological measures is crucial for validating the emotional responses that individuals experience in architectural spaces (Mallgrave & Gepshtein, 2021).

9.6 The Corridor Experiment

The corridor experiment explored the priming effects of atmospheric affordances in architecture, particularly focusing on the role of light as a generator of emotional experiences. Inspired by the idea that our embodied engagement with atmospheric stimuli influences subsequent spatial experiences—often without our conscious awareness—the study aimed to investigate whether different atmospheric qualities in a corridor could prime emotional responses in a subsequent space, much like how sound in films shapes audience emotions without explicit attention (Canepa et al., 2019).

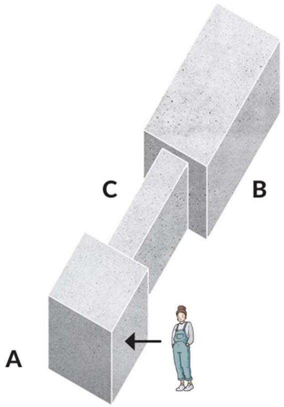
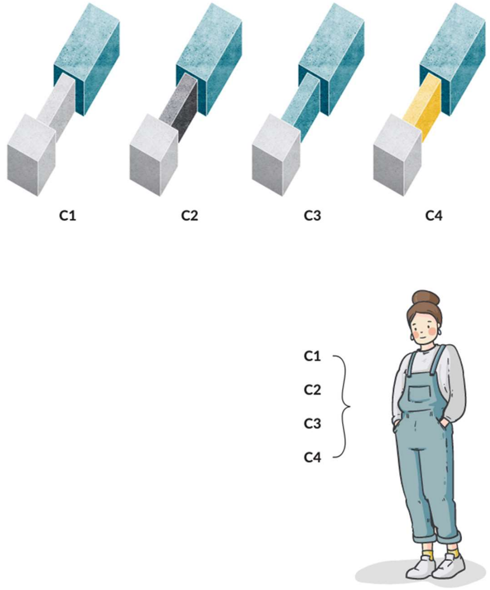


Figure 9.1 Resonances Experiment: Corridor Variations - (Beighle, K., Canepa, E., Condia, B., Djebbara, Z., & Mallgrave, H., 2023).

The experiment involved a series of virtual reality (VR) simulations, where participants explored four different corridor iterations. Each corridor connected two rooms, with the starting and ending rooms remaining constant in terms of layout, light, and design. The corridors, however, varied in light quality—brightness and color—across four conditions: (1) a bright corridor consistent with the starting room, (2) a dark corridor creating contrast, (3) a blue corridor matching the final room, and (4) an amber corridor providing contrast with the ending space (Canepa et al., 2022b). This experimental setup allowed the researchers to assess how changes in light might influence emotional resonance and attunement as participants transitioned between spaces.

Figure 9.2 Resonances Experiment: Corridor Variations - (Beighle, K., Canepa, E., Condia, B., Djebbara, Z., & Mallgrave, H., 2023).



Participants' emotional responses were measured through both first-person self-reports and third-person physiological data. Upon entering the final room, participants completed a questionnaire evaluating their emotional experience in terms of arousal, valence, and dominance, which are commonly used dimensions to describe emotional responses (Lang et al., 1993). These self-reports were complemented by neuroscientific measures, including electrodermal activity (EDA), skin temperature, and heart rate—all sensitive markers of autonomic nervous system activity that reflect nonconscious emotional arousal (Subramanian et al., 2021). This dual approach allowed the researchers to assess both conscious feelings and nonconscious bodily responses to the different corridor atmospheres.

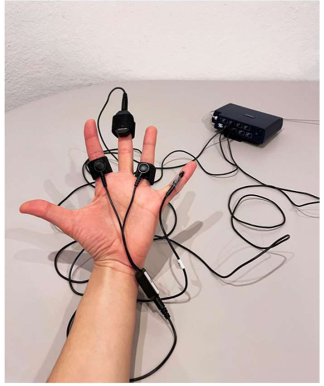


Figure 9.3 Resonances Experiment: wearable sensors for tracking physiological arousal - (Beighle, K., Canepa, E., Condia, B., Djebbara, Z., & Mallgrave, H., 2023).

The findings of the study suggested that light manipulation was a powerful atmospheric generator, evoking significant emotional responses regardless of the participants' empathic disposition. The results demonstrated that subtle shifts in environmental conditions—such as the brightness and color of a corridor—could prime participants' first impressions and emotional engagement with the subsequent space (Canepa et al., 2019). This priming effect highlights the critical role of atmospheric resonance, where architectural elements influence not only the immediate perception of space but also the emotional tone of the experiences that follow.

Ultimately, this experiment offers insights into the intricate relationship between architecture and emotional experience, advancing our understanding of how nonconscious emotional priming operates in designed environments. By combining phenomenological and biological perspectives, the research contributes to a broader framework for designing atmospheres that actively engage and shape human emotions, thus enhancing the emotional and sensory impact of architectural spaces (Canepa et al., 2022b).

10. NONCONSCIOUS ADAPTIVE SKILLS

Timothy Wilson argues for the term "nonconscious" as it avoids psychoanalytic baggage and fits better with cognitive neuroscience. The nonconscious is notoriously difficult to define, but it refers to mental processes that are inaccessible to consciousness yet influence judgments, feelings, or behavior. These processes allow us to interpret environments and initiate behavior effortlessly, providing a significant biological advantage by making interactions manageable. Without these skills, our interaction with the world would be overwhelming.

An example of our adaptive skills failing is seen in Simons and Levin's (1998) experiment on change detection. They had two researchers ask pedestrians for directions. During the conversation, two others carrying a door walked between the pedestrian and the researcher, allowing the researchers to swap places. Despite differences in voice, appearance, and clothing, only 7 out of 15 pedestrians noticed the change. This highlights our limited attentional resources during a task, where attention actively suppresses noisy information to make important pieces stand out.

Adaptive nonconscious processes are not always accurate and are limited by our attentional resources, available sensed information, and prior experiences. For architects, this means their designs often go unnoticed in everyday life as people's conscious thoughts are occupied by other tasks. Walking through a city, we interact with architecture nonconsciously, moving effortlessly through the environment while focusing on primary tasks like social plans or dinner.

Suppression dynamics play a crucial role in our attentional resources and awareness. The sensory system constantly samples information about the environment and internal organs to maintain a homeostatic balance. Peripheral (visual) information often holds little value relative to an ongoing task, which is why it gets suppressed. However, this suppressed information is phenomenologically rich and constantly affects us beyond our awareness.

Experiments in selective attention, like the Monkey Business Illusion, demonstrate that while irrelevant information is tuned out, it is not entirely lost. It remains rich to our nonconscious adaptive skills. Studies on optic flow show that changing visual information can affect walking speed and behavior, suggesting that our adaptive skills use sensory feedback to control actions.

Everyday interaction with architecture affects us through these nonconscious peripheral dynamics, which manifest in our bodies and behavior. Sensorimotor dynamics, the study of how sensory information affects motor actions, reveal how the brain integrates sensory and motor information to produce nonconscious adaptive behaviors.

Ultimately, nonconscious adaptive skills require no conscious effort—they just happen in the background of our lives, setting the contextual constraints through nonconscious sensorimotor adaptation. This systematic suppression of irrelevant signals frees up attentional resources for other tasks

10.1 Homeostasis and Process-Oriented Architecture

Biology offers two key lessons that are essential for understanding how the brain interacts with architecture. First, organisms adapt to environmental changes, and second, all biological systems exhibit rhythmic or oscillatory behavior. These principles provide insight into how the brain engages with built environments. Winston Churchill's famous remark—"we shape our buildings, and thereafter they shape us"—captures the essence of this interaction. However, biological evidence suggests that it was the environment that shaped us first, long before we gained control over it. This interaction is a continuous, dynamic process, which can be best understood through the concept of homeostasis.

Homeostasis refers to the body's ability to maintain internal balance in response to external changes (Damasio 2010). For instance, when an organism perceives a cold environment, it compensates by moving to a warmer place or generating heat to restore balance. Timing is crucial in these adjustments, as failure to act swiftly could result in irreversible damage (Sterling 2012). This dynamic responsiveness is a core function of all living organisms and is essential for survival.

Process philosophy provides a broader framework for understanding these biological rhythms in relation to architecture. Rather than focusing on static forms, this perspective emphasizes the importance of time, change, and dynamics in life processes (Dupré 2014; Nicholson and Dupré 2018). The environment continuously influences our bodies through rhythmic sensory-motor interactions. Our perception of spaces and architecture is not a passive process but an ongoing engagement between sensory input and motor responses. This oscillatory nature of perception ensures that we remain attuned to changes in our surroundings.

Inactivism, a theory that aligns with process philosophy, argues that cognition is deeply intertwined with our bodily experiences and environmental interactions. Rather than merely responding to stimuli, organisms continuously adapt to their environments in a dynamic process of synchronization between sensory and motor systems (Varela, Thompson, and Rosch 2016). This concept reinforces the idea that architecture should be designed not just as a static entity, but as a temporal and adaptive environment that interacts with its inhabitants. The rhythms of architecture, like those of the body, unfold over time, continuously shaping and being shaped by the individuals within.

10.2 Rhythms of Atmosphere and Perception

The argument is not that atmospheres can directly generate measurable brain waves, but rather that they subtly exist within our sensorimotor suppression space, influencing our behavior and experiences in ways that may go unnoticed. To grasp this concept more fully, consider a thought experiment involving three distinct spaces—A, B, and C. Imagine moving from space A to B, and then from space C to B. Although space B remains the same, your experience will differ depending on the sequence. This is because our present experience is shaped by both our immediate past and anticipated future, creating a continuous integration of sensory and motor capacities (Husserl 2001; Fuchs 2007).

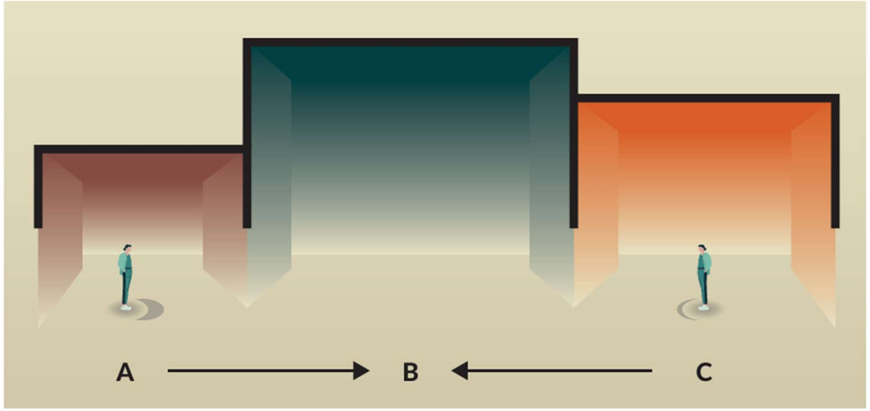


Figure 10.1 A thought experiment of transitions to emphasize the importance of time when thinking about the experience and impact of the built environment. With three different spatial configurations, will the experience of space B be similar if we approach it from space A or space C? - (Beighle, K., Canepa, E., Condia, B., Djebbara, Z., & Mallgrave, H., 2023).

This principle of continuity highlights how we perceive atmospheres not as isolated, static entities, but as part of an ongoing temporal process. Our perception is an immediate contrast between past and future, influenced by both our environment and prior experiences (Albarracín and Wyer 2000; Raviv, Ahissar, and Loewenstein 2012; Brügger, Demski, and Capstick 2021). In this way, atmospheres can be thought of as the backdrop to our conscious awareness, affecting us nonconsciously through the rhythms of our surroundings.

An architectural example that illustrates how atmospheres are shaped by the sequence of experiences can be found in the Romanesque Crusader's Abbey of Sant'Antimo, located in Tuscany, Italy. Upon entering the church from the bright outdoors, one is immediately struck by the shift from light to darkness, an experience that primes the senses for what follows. The sudden change in lighting, combined with the lingering fragrance of incense and the resonating tones of Gregorian chants, transforms the perception of the space. The rhythmic interplay of these sensory elements creates an atmosphere that feels tailor-made for this precise moment, as if the architecture itself was designed to heighten the emotional and spiritual experience of the visitors. The cool stone walls, pierced by shafts of sunlight reflecting off Roman columns, contribute to a sense of timelessness and reverence. This example demonstrates how the atmosphere of the abbey is not static but unfolds as part of a temporal process, where the past (the bright exterior) and the present (the dim, sacred interior) interact to shape the perception of the space. This continuous integration of sensory inputs aligns with the idea that atmospheres are perceived as dynamic, fluid experiences influenced by prior encounters and the rhythms of our surroundings (Husserl 2001; Fuchs 2007).

Figure 10.2 The Romanesque Crusader's Abbey of Sant'Antimo, located in Tuscany, Italy - reddit.com

Attention plays a key role in shaping how we experience atmospheres. It acts as a funnel, directing our focus and often suppressing peripheral information. To fully perceive an atmosphere, one must become attuned to its sensory qualities over time, a practice that requires effort and is akin to open-monitoring meditation (Lutz et al. 2008). Yet in everyday life, our interaction with atmospheres tends to remain in the background, available when needed but not at the forefront of our attention. Contextual information, such as lighting conditions or the presence of others, also plays a significant role in shaping our perception and behavior.

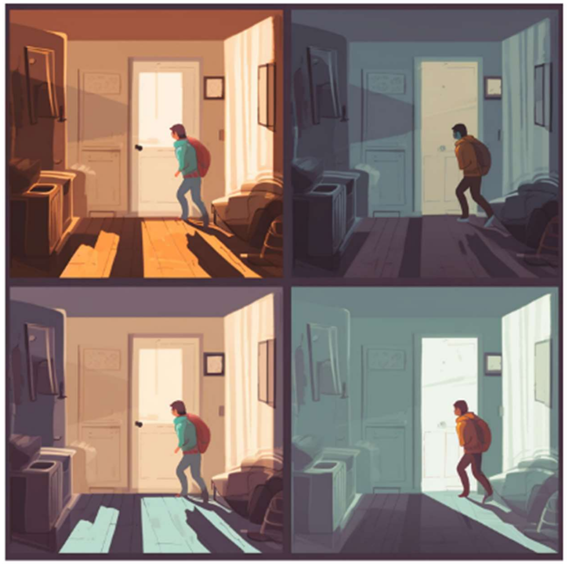


Figure 10.3 Variations of the same scene with different atmospheres. Although we fixate on the person in the picture, our peripheral vision continuously informs us about the atmospheric quality of the scene. This series of pictures do not make justice to this real-world effect, however, it captures the gist of it - (Beighle, K., Canepa, E., Condia, B., Djebbara, Z., & Mallgrave, H., 2023).

In architecture, these subtle cues—like shifts in lighting—can dramatically affect our experience of space. The slow rhythms of natural light, such as during a sunrise or sunset, are examples of environmental rhythms that subtly shape the atmosphere. Man-made atmospheres, with their faster-changing rhythms, can reset our perception as we move from one space to another (Zumthor 2006). Thus, atmospheres operate in the background, influencing our cognition and behavior without us being fully aware of their impact.

10.3 Transthalamic Transmission and Its Role in Cognitive Processing

The thalamus, a central hub within the brain, is anatomically divided into around 60 distinct nuclei, each intricately connected to the cortex (Jones 2007). Understanding the interaction between the cortex and the thalamus poses significant challenges, particularly in terms of both upward and downward communication pathways. Nearly all sensory information, excluding olfactory signals, passes through the thalamus before it reaches the neocortex, where it can be processed for cognitive and behavioral functions (Buzsáki 2019). The thalamus thus occupies a pivotal role in coordinating sensations, being situated in a subcortical region that interacts with other key structures involved in movement and sensory functions (Cover et al. 2023). Additionally, motor-related processes are closely tied to subcortical connections, influencing core cognitive abilities such as memory, attention, and learning (La Terra et al. 2022; Wolff, Ko, and Ölveczky 2022).

The conventional view of the thalamus is that of a relay station, selectively filtering out irrelevant sensory information, enabling the cortex to process only what's immediately pertinent. This function is crucial in scenarios such as focusing on a conversation in a crowded room by ignoring surrounding noise. This perspective led to the prevailing assumption that consciousness, an essential element for cognition and behavior, emerges primarily through cortico-cortical connections, or direct interactions between different parts of the cortex (Rees, Kreiman, and Koch 2002; Dehaene and Changeux 2011; Koch et al. 2016). In this traditional framework, the thalamus is seen merely as a passive mediator of sensory information, while higher cognitive functions, particularly those governed by the prefrontal cortex, are thought to drive complex cognitive processes (Brown, Lau, and LeDoux 2019).

In contrast, the transthalamic model presents the thalamus as more than a simple relay. This view proposes that the thalamus plays an active role in interregional communication, bridging different cortical areas to facilitate cognitive functions like memory, attention, and perception (Sherman and Guillery 2011; Sherman 2016). According to this model, the thalamus serves as a conduit for cortico-thalamo-cortical pathways, supporting the integration of sensory and cognitive information across multiple brain regions (Kastner, Fiebelkorn, and Eradath 2020; Eradath, Pinsk, and

Kastner 2021). This shift in understanding highlights the thalamus as a dynamic processor, actively involved in transmitting information to support higher-order cognition.

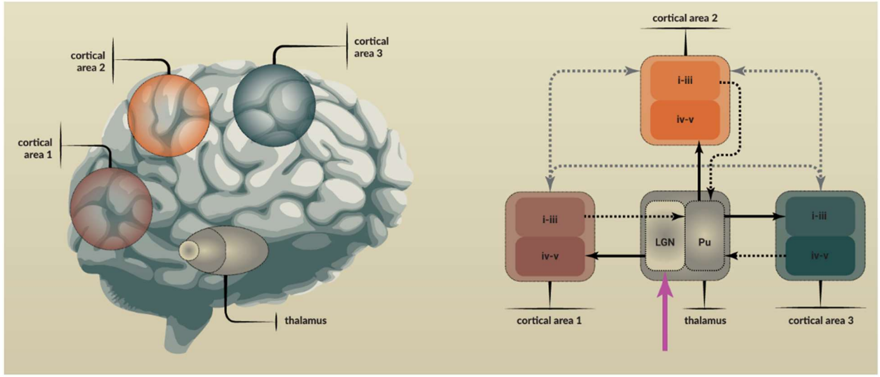


Figure 10.4 The left side portrays the position of the thalamus and the cortical areas relative to each other for cortical areas relevant to the built environment – (Djebbara, Fich, and Vecchiato 2022). The right side portrays their connections, where the dashed lines represent the higher-order connections, the solid lines represent the first-or cortical area 2 3 — Rhythms of the brain, body, and environment cortical area 1 der connection, and the gray dashed lines represent the cortico-cortical connections. The magenta arrow represents the ascending peripheral sensory information. The Roman numerals represent the layers in the neocortex. This schematic is highly simplistic example of the relationships (LGN: lateral geniculate nucleus; Pu: pulvinar).

Research supporting this transthalamic perspective has revealed that the thalamus engages in two types of connections. The first is first-order connections, where sensory information is relayed directly from the thalamus to the cortex, such as in the case of visual input passing through the lateral geniculate nucleus to the primary visual cortex. The second, more complex type is higher-order connections, which are thought to play a pivotal role in integrating information between distinct cortical regions, essentially acting as bridges for cognitive communication (Sherman and Guillery 2006). Notably, studies have shown that descending cortico-thalamic connections outnumber ascending thalamic inputs by a significant margin, suggesting that these connections may serve an associative or feedback function, linking sensory input with cognitive processing (Guillery 1995; Wolff et al. 2021).

This transthalamic approach contrasts sharply with the dominant cortico-cortical model by emphasizing the interactive role of the thalamus in shaping cognition and behavior. While the cortico-cortical model views sensory information as a static representation of the environment, the transthalamic view considers sensory input as dynamically integrated with ongoing neural processes, making it more susceptible to the environmental context. As such, the transthalamic model opens up the possibility that atmospheres, particularly in architectural spaces, could influence cognitive processing by modulating the sensory information relayed through the thalamus. This insight aligns with recent research suggesting that sensory environments, such as the built environment, can impact cognitive functions indirectly by influencing thalamic transmission pathways (Saalmann and Kastner 2009, 2011; Cover et al. 2023; Cortes et al. 2020, 2021).

The significance of the transthalamic perspective lies in its potential to deepen our understanding of how atmospheres affect human cognition and behavior. If architectural environments can alter sensory transmission through the thalamus, they may have far-reaching effects on how we perceive and interact with spaces. This emerging view does not focus on the subjective experience of atmospheres but rather on how atmospheres influence our cognitive abilities, such as attention and memory, through their impact on sensorimotor dynamics that operate outside our conscious awareness.

Thus, the hypothesis emerging from this research is that atmospheres can unconsciously affect our adaptive behaviors through their subtle influence on thalamic pathways. This interaction between environmental stimuli and transthalamic processing suggests that our cognitive and behavioral responses are continuously shaped by the background presence of sensory information, even when we are not explicitly aware of it. Understanding this connection could offer architects new tools for designing spaces that subtly enhance or regulate cognitive functions through the manipulation of sensory inputs at the thalamic level.

11. COGNITIVE AND BEHAVIORAL RESPONSES TO ARCHITECTURE

Ecological psychology, pioneered by J. J. Gibson and E. J. Gibson, presents a unique approach to cognition by emphasizing the interconnectedness of perception and action within an organism-environment system. This perspective challenges traditional dichotomies such as perception versus action and mind versus body. Instead, it focuses on how organisms interact with their environments holistically, considering both the physical and cognitive aspects of these interactions. The ecological approach provides valuable insights into how architectural design can influence human behavior and well-being, making it a crucial concept in neuroarchitecture.

11.1 The Principle of Perception/Action

Ecological psychology reframes the relationship between perception and action as a reciprocal, continuous, and mutually constraining process. Unlike traditional theories, which view perception as a passive reception of sensory information and subsequent internal processing, the ecological approach posits that perception is an active exploration of the environment. This concept, pioneered by J. J. Gibson, suggests that perceiving is an act of engaging with the world to directly gather information necessary for action.

For example, when navigating a space, individuals do not simply see a chair as an object. Instead, they perceive the chair in terms of potential actions—sitting, leaning, or even using it as a step stool. This perception is inherently tied to the individual's current needs, intentions, and capabilities. As Gibson stated, "perceiving is an act, not a response, an act of attention, not a triggered impression, an achievement, not a reflex" (Gibson, 1979, p. 149).

This understanding of perception as action emphasizes the dynamic nature of human interaction with the environment. It also highlights the importance of designing spaces that facilitate natural and intuitive interactions. In neuroarchitecture, incorporating principles of perception/action means creating environments that are not only aesthetically pleasing but also functionally supportive of the activities they are intended to accommodate. By designing spaces that align with the natural tendencies of human perception and action, architects can enhance user experience and well-being.

11.2 The Principle of Affordance

The principle of affordance, introduced by J. J. Gibson, refers to the potential actions that an environment offers to an organism. An affordance is not merely a property of an object but a relational characteristic that emerges from the interaction between the organism and the environment. For example, a chair affords sitting for humans because of their physical capability to sit. However, the same chair might afford different uses for different creatures, such as hiding under it for a small animal.

This principle underscores the importance of designing environments that provide clear cues for interaction, making it easier for users to navigate and utilize spaces effectively. Research has shown that affordances are perceived directly through the body's interaction with the environment. Warren's (1984) study on stairways demonstrated that the affordance of climbability is not an intrinsic property of the stairway itself but a relational property dependent on the individual's leg length. This relational understanding of affordances highlights the need for designs that consider both environmental properties and the physical capabilities of users.

In neuroarchitecture, focusing on affordances means creating environments that enhance usability, accessibility, and overall satisfaction. By designing spaces that align with users' physical and cognitive abilities, architects can create more intuitive and supportive environments. This approach not only improves functionality but also promotes well-being by reducing stress and increasing comfort.

11.2.1 The Object Affordance

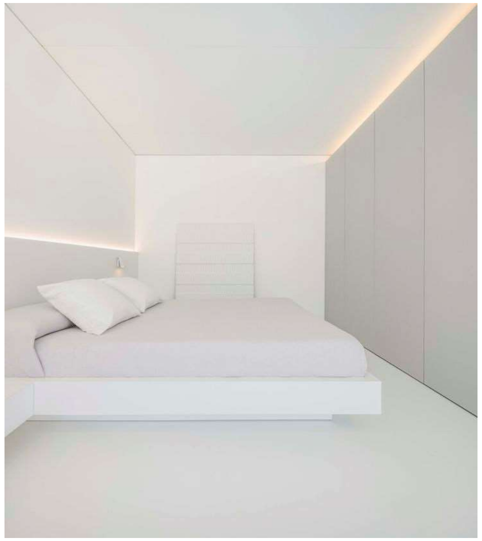
The concept of "object affordance" highlights how the human brain instinctively identifies objects as graspable, influencing our perception and interaction with a space (Jeannerod et al., 1995; Portugali, 1996). This unconscious reaction is triggered by objects that appear to fit within the average hand size, typically between two to eight centimeters. When such objects are present in our immediate surroundings, they evoke neurological and muscular responses, preparing our bodies to engage with them. Even without physical contact, the mere availability of these graspable elements fosters a sense of comfort and reassurance, as they signal the environment's accessibility and readiness for interaction (Garrido-Vasquez & Schubo, 2014; McBride et al., 2012).

A positive connection between humans and their environment can be reinforced by several factors related to object affordance. Items such as handles, edges, trims, frames, or decorative designs that are visually appealing and sized for easy grasping create a subconscious invitation for interaction. Although people may never actually touch these elements, their presence alone satisfies a psychological and physiological need for tactile engagement. Smooth, rounded surfaces are particularly effective in evoking this response, as they appear comfortable to hold, even in their visual form. Conversely, rough, angular, or sharp objects can trigger negative reactions, as they signal potential harm or discomfort, discouraging interaction (Jeannerod et al., 1995; Sussman & Hollander, 2015).

The strength of object affordance also depends on proximity. Elements that are within easy reach naturally elicit a stronger connection than those farther away. However, when graspable objects are out of reach or designed in ways that disrupt their accessibility, the connection diminishes. In addition, transparent or amorphous objects fail to generate the same sense of interaction because they are perceived as intangible, limiting the instinctive response to grasp or touch them.

Despite the subconscious importance of this human-environment interaction, modern minimalist design often disregards the need for tactile engagement by intentionally omitting graspable elements. This design philosophy frequently eliminates visual and physical cues that would otherwise invite touch or connection, focusing instead on clean, uninterrupted lines and surfaces. Even when structural elements like frames or supports are present, minimalist designs often make them too small or too large to fit comfortably within the hand. The result is an aesthetic that frustrates the object affordance mechanism, leaving individuals feeling disconnected from their surroundings (Pallasmaa, 2009).

As Pallasmaa notes in The Thinking Hand, this lack of tactile engagement prevents users from forming a deep, instinctive connection with the space. While minimalist environments may appeal to a modern design sensibility, they often fail to engage the "thinking hand"—the instinctive human desire to reach out and physically interact with the surroundings. By ignoring the human body's natural response to touch, such designs inadvertently create spaces that can feel cold, alienating, and less supportive of psychological well-being. Therefore, object affordance remains a crucial consideration for fostering positive emotional and physical interactions within architectural spaces.



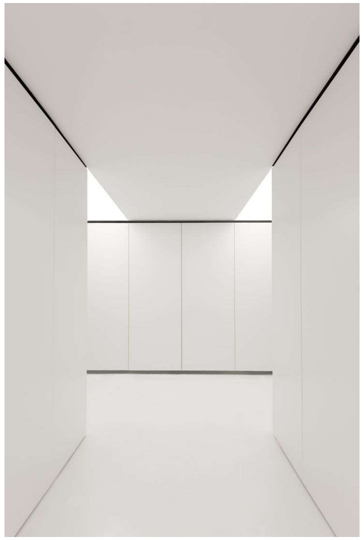


Figure 11.1 N70 NIU House / Fran Silvestre Arquitectos, Archdaily
Figure 11.2 The Stone Atelier - fransilvestrearquitectos.com

11.2.2 Scale dependence on small things

The small details in a room—like windows, doors, furniture, and decorations—are important because they affect how larger architectural elements work. As Salingaros (2006) points out, “larger scales depend on smaller ones, but not the other way around”. This means that while big parts of a building rely on smaller parts to function well, the small details can exist and make sense even without the larger parts. For example, smaller things like door handles, furniture, or window trims, which fit within the human body’s proportions—such as the size of our hands, arms, or height—help shape how we experience and use a space. These smaller elements, from 1 millimeter to 2 meters in size, play a big role in making buildings feel comfortable and useful, beyond just looking nice.

When designing a building, no single size or scale should be ignored, because all scales work together to make the space functional. Focusing only on large structures, as is common today, often leads to designs that don’t feel right to the people using the space. Even though small and medium-sized details may not seem important for the overall look or strength of the building, they are key to supporting the entire design system.

Humans interact with their surroundings on many levels, especially through small and medium-scale details. The smallest elements, such as textures in natural materials, are often present in materials like wood or stone, though larger patterns or textures also appear naturally. However, these graspable elements, like handles or other small features, usually don’t form on their own in natural materials, so designers need to intentionally include them. This goes against the minimalist design trend, which tends to leave out small, graspable features, but these details are important for creating a comfortable and engaging space.

Our well-being in a space depends on the small and medium-sized elements that help define it. Our brain processes these details as part of the whole room, making it either feel comfortable and cohesive or disconnected. Traditional architectural features like frames, moldings, and trims, which minimalist designs often leave out, are necessary—not just for decoration, but because they help our brains make sense of the larger space.

Removing these small details puts extra pressure on the larger parts of the building, requiring them to be built with extreme precision, which can be costly. Without these smaller elements, designs are limited to using standard, large-sized pieces, which reduces the flexibility and adaptability of the space. Often, construction budgets are wasted on trying to achieve "machine-like precision," which doesn't improve the user’s experience or well-being. While architects might appreciate precise lines due to their training, most people do not notice or benefit from it.

In reality, stripping away details doesn’t make a building more useful or adaptable. Instead, it reduces its ability to serve the needs of the people using it, making the space feel more like an industrial warehouse. This problem is evident in spaces that have been oversimplified through modern design methods.

A room that is built to standard dimensions, with fixed ceiling heights and window placements, won’t fit most people’s emotional or practical needs. It also can’t be reused effectively for different purposes, climates, or cultures because each situation requires different sensory and cognitive cues to feel psychologically healthy. This challenges the idea of a one-size-fits-all "International Style" of architecture, which ignores the complexity of human nature and the importance of designing spaces that support people’s well-being.

Figure 11.3 NS Residence, Michelle Wentworth - ignant.com

Figure 11.4 NS Residence, Michelle Wentworth - ignant.com

11.2.3 Moldings, Window Frames, and Concave Designs

Rooms with concave, curved walls are often seen as more inviting and comfortable. These features, along with the idea of "object affordance," work together to suit our brain's natural responses to spaces. Starting with small details, traditional moldings typically combine concave and convex shapes: the concave part creates a sense of enclosure or "being held," while the convex part gives us something to mentally "grasp." This balance of shapes makes traditional moldings important for more than just decoration—they provide psychological comfort by connecting us to the space's curved, concave boundaries.

Figure 11.5 Interior Design - pinterest.com

Interestingly, the effect of these small design elements is nonlinear, meaning that even though moldings or curved walls are small, they have a big emotional impact. Our brain is wired to notice small details that can affect our sense of safety and comfort, so eliminating these elements based on their size is a mistake. They may be small, but they play a large role in how we feel in a space.

In traditional architecture, crown moldings, which are often concave, are used where walls meet the ceiling. These moldings can be narrow or cover a larger area, sometimes even forming a fully vaulted ceiling. Even a small strip of molding along the ceiling can improve the feeling of comfort in a room, giving us a subconscious sense of being "wrapped" in the space. This design choice can also improve the acoustics of the room.

Figure 11.6 Interior Design - pinterest.com

Figure 11.7 Interior Design - pinterest.com

Another example of how "object affordance" and concave shapes work together is seen in traditional bay windows (Alexander et al., 1977). These windows create a cozy, protected space while allowing a view of the outside, blending the concepts of "refuge" and "prospect" (Kellert et al., 2008; Salingaros, 2015b). This contrasts with modern glass curtain walls, which offer no sense of protection. In bay windows, it's not just the glass that matters; the frames, grids, and mullions between the windowpanes provide the psychological comfort of enclosure. These small frames are often just the right size to hold, satisfying our brain's need for "graspable" objects (Alexander et al., 1977). In contrast, large panes of glass with little or no framing create a feeling of unease, rathe

than a reassuring sense of enclosure. Our brain's natural response supports traditional window designs over large, unframed glass walls.

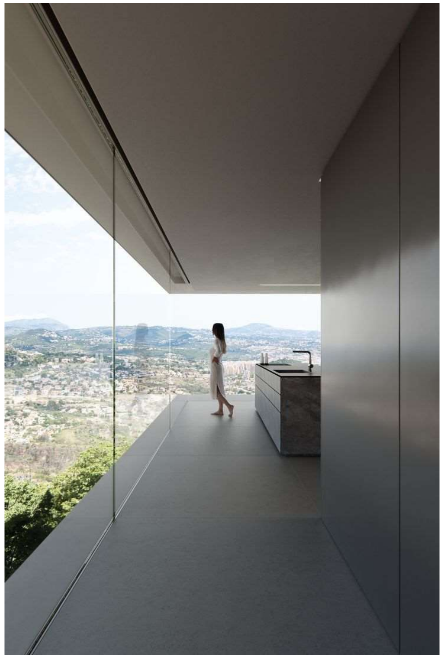


Figure 11.8 Fran Silvestre Arquitectos - pinterest.com

Figure 11.9 Interior Design - pinterest.com

11.2.4 Incorporating All Our Senses

The information we gather from our environment acts like an invisible force field that connects us to the spaces around us, even though there isn't any physical interaction involved. Many modern buildings lack the thoughtful details and features that create a welcoming atmosphere. When architects use abstract designs without considering how people will react, the result can be spaces that feel threatening or oppressive. As a result, users may avoid these areas or feel uncomfortable when they have to use them, experiencing increased stress instead. Choices that seem harmless in design can lead to negative physical responses because the consequences are often overlooked or misunderstood.

A space intended for a specific function might not support the behaviors we expect, or it could feel awkward due to our body's instinctual reactions to the geometry, textures, and overall complexity—or simplicity—of the environment. These subtle interactions can send strong signals to our bodies, guiding our behavior in straightforward ways. This instinctual response is more fundamental than psychological or medical aspects, forming the foundation of architecture and design.

Our sensory system is always processing environmental cues, which trigger physical responses throughout our bodies. This reaction involves contributions from all our senses, including sight, hearing, smell, balance, touch, and even invisible factors like infrared radiation from hot or cold surfaces. These sensory inputs operate on various scales and distances, influencing how we interact with our surroundings.

In his book The Eyes of the Skin (1996), Juhani Pallasmaa highlights the importance of non-visual senses in how we experience and understand our environment. While this book is often included in architecture curricula, it doesn't seem to influence practice as intended. Architects reference it frequently, yet many designs overlook the qualities it emphasizes. Instead of encouraging sensitivity to these non-visual aspects that can alleviate anxiety, traditional design education tends to prioritize formal styles and visual appeal.

12. WINNERS OF THE MUSEUM OF EMOTIONS COMPETITION EDITION #5

1st Winner Beautifully Cruel by Minseok Choi and Jang Doyeong (South Korea)

Figure 12.1 1st Prize Winner, Museum Of Emotions Edition #5 - Buildner.com

Jury feedback summary

“This project contrasts two very different environments to explore the relationship between architecture, nature, and human experience. The exterior blends with the surrounding landscape, featuring a floral envelope that changes with the seasons, emphasizing time and connection to nature. In contrast, the interior is dark, static, and introspective, creating a stark spatial and emotional divide. By integrating plant life into the structure, the project exposes hidden ecological systems and challenges conventional architectural boundaries. Using minimal materials and natural light, it balances openness and seclusion, offering a reflective space while addressing sustainability and the integration of natural elements in design.” (Buildner Architecture Competitions, n.d.)

2nd Winner Borderline by Hongyang Deng, 闫 明, and Jianing Guo (China)

Figure 12.2 2nd Prize Winner, Museum Of Emotions Edition #5 - Buildner.com

Jury feedback summary

"This project uses a curvilinear form to create a strong connection between the landscape and the shoreline, guiding visitors along a path that evokes a progression of emotional and spatial experiences. The wavy design gestures both soften and emphasize the dramatic boundary of the cliff, directing views alternately towards the land and the sea. This careful integration respects the natural context while offering a protected space for reflection and play. The design captures the duality of its site—the joy of a verdant landscape alongside the stark edge of the shoreline—offering a thoughtful exploration of topography and human interaction with nature." (Buildner Architecture Competitions, n.d.)

3rd Winner Emotional Landscape by Thomas Tovar and Samantha Rodriguez (USA)

Figure 12.3 3rd Prize Winner, Museum Of Emotions Edition #5 - Buildner.com

Jury feedback summary

"This project explores the interplay between architecture and nature to offer a tranquil, atmospheric space that straddles the boundary between interior and exterior. The design features a cave-like enclosure and a cantilevered platform, creating contrasting yet complementary experiences. These elements harmonize with the natural setting, enhancing a sense of simplicity and elegance. The project's transitions, such as the pathway and thresholds, are carefully designed to guide visitors through a journey that balances enclosure and openness. While its monochromatic presentation emphasizes universality, the design's nuanced approach to space and context creates a unique architectural expression rooted in contrasts and continuity." (Buildner Architecture Competitions, n.d.)

13.Conclusion

This thesis has explored the profound relationship between architecture and human emotion, underscoring how the built environment influences our psychological and emotional states. Through an extensive review of the competition for the Museum of Emotions, scientific foundations, and contemporary methods in neuroarchitecture, this work aimed to illuminate the ways in which architecture serves as both a canvas and a catalyst for emotional experiences. By linking scientific research with artistic intuition, it became clear that architecture operates at the intersection of empirical knowledge and creative expression.

However, despite significant advancements in understanding how architecture affects emotions, this research highlights a key insight: there is no definitive set of rules or universal standards that dictate how to design for specific emotional outcomes. The variability of human perception, the influence of personal experiences, and the ever-evolving nature of architectural practice make it impossible to reduce design to a prescriptive formula. While scientific principles—such as those derived from Gestalt psychology, ophthalmology, and neuroscientific methods—offer valuable insights, they are not rigid guidelines. Architecture remains a dynamic dialogue between science and art.

13.1 Summary of Key Findings

One of the most important findings of this research is the understanding that architectural elements, such as light, perspective, and spatial configuration, can profoundly shape emotional responses. The Museum of Emotions competition underscored the potential of architecture to elicit both positive and negative emotional experiences, depending on the deliberate manipulation of these elements. It also became clear that emotional experiences within architecture cannot be predicted with absolute certainty, as individuals bring their own personal histories and sensitivities into any spatial encounter. Additionally, neuroscientific methods such as fMRI and EEG offer a new frontier for objectively measuring emotional responses to architectural spaces, providing valuable insights into how we subconsciously engage with our surroundings. However, these methods still have limitations and cannot fully account for the subjective and non-conscious aspects of emotional experience.

13.2 Implications

These findings suggest that architecture, more than ever, should be seen as a discipline that intertwines scientific knowledge with creative expression. While scientific tools provide architects with valuable data on how spatial environments can influence emotions, the true power of architectural design lies in its ability to transcend data and evoke nuanced, deeply personal emotional experiences. For the field of neuroarchitecture, this research reinforces the need for continued interdisciplinary collaboration. Architects should engage not only with neuroscientists but also with psychologists, urban planners, and sociologists to create spaces that are attuned to human well-being in a more holistic sense. This research also has broader implications for mental health and urban design, as it suggests that spaces can be consciously designed to support emotional and psychological well-being. As architects take on the responsibility of creating environments that nurture positive emotional experiences, they must also remain open to the inherent unpredictability and subjectivity of human emotion.

13.3 Future Research

There are several areas for further investigation that stem from this thesis. One critical area is the continued exploration of neuroscientific methods, especially as they become more accessible and refined in their ability to measure emotional responses to architecture. Future research could focus on developing new tools for architects to use these insights in practical design processes, allowing for a more seamless integration of science into creative work. Another promising area of study is the impact of cultural, social, and historical contexts on emotional responses to architecture. While this thesis has focused largely on universal aspects of emotional perception, understanding how different cultures or social groups experience space could provide a richer, more inclusive approach to emotional design. Lastly, investigating the potential of virtual and augmented reality as tools for designing emotional atmospheres in architectural spaces could open up new possibilities for experimentation and innovation.

13.4 Final Thoughts

Much like other complex fields where human experience plays a key role, architecture must navigate a balance between structured knowledge and the freedom to innovate. Some suggest that scientific findings could be distilled into clear building regulations, while others propose a collaborative, research-driven approach that encourages exploration before construction. Neither method alone can fully encapsulate the nuance of emotional design. Too many rules may stifle creativity, but complete freedom without structure might lead to missed opportunities in understanding how specific designs impact users.

In this context, a new role could emerge in architectural practice: one that bridges scientific research and design, translating cognitive neuroscience findings into principles that inform design without constraining it. Architects, much like doctors or engineers, could benefit from a framework that respects both the rigor of scientific inquiry and the unpredictability of human experience. At the same time, it is essential to maintain the freedom for designers to interpret and personalize these principles, allowing for varied and unique architectural projects.

In conclusion, the future of architecture lies not in establishing rigid frameworks, but in cultivating a deeper understanding of how architectural spaces resonate with individuals on emotional, psychological, and sensory levels. This thesis is a step toward that goal, providing a foundation for further exploration while acknowledging the complexity and subjectivity inherent in both the design process and human experience. By continuing to integrate scientific insights with artistic innovation, architects can create spaces that not only serve functional purposes but also elevate and transform the emotional landscapes of those who inhabit them. Ultimately, architecture is not just about designing buildings; it is about shaping the way we experience and interact with the world around us, and in doing so, it holds the potential to profoundly enhance the quality of human life.

Architects should understand not only how much architecture can affect emotions but also how it does so. By 'how,' I mean acknowledging the scientific aspects of human perception and the theories surrounding this topic, while keeping them in mind throughout the design process, each in their own creative way. In other words, it's like giving a group of chefs the exact same ingredients without telling them what dish to cook.

GLOSSARY

Conceptual Clarifications

In order to frame this thesis, it is important to establish a clear understanding of the key concepts and disciplines that intersect with the study of architecture and emotions. This section will map out the primary research fields, including neuroscience, neuroarchitecture, and bibliophilic design, highlighting their respective approaches to architectural practice. While these areas inform the broader discourse, the focus of this thesis remains sharply specific, concentrating on the emotional perception of architectural atmospheres.

Traditional Architectural Approaches

Historically, architecture has always engaged with the emotional dimension of space, long before neuroscience entered the picture. Traditional approaches rely on centuries of architectural knowledge about how certain forms, proportions, and spatial arrangements impact the human psyche. These methods, grounded in the aesthetic theories of thinkers like Vitruvius, Le Corbusier, or Christopher Alexander, have shaped how architects intuitively create spaces that evoke awe, tranquility, or tension. While traditional methods lack the empirical validation provided by neuroscience, they have been successful in generating emotional responses that are now being studied through neuroarchitectural lenses. For example, Gothic cathedrals with their soaring heights and intricate details have long been known to inspire feelings of reverence, a phenomenon that neuroarchitects now analyze in terms of brain activity related to spatial perception and emotional arousal.

Bibliophilic Design

Bibliophilic design, rooted in the concept of biophilia—the human tendency to seek connections with nature—is often seen as complementary to neuroarchitecture. However, it is distinct in its emphasis on integrating natural elements such as greenery, sunlight, and organic materials into built environments. This design approach is supported by evidence that exposure to nature, even when mediated through architectural design, has restorative effects on both mental and physical health (Kellert, 2008). Biophilic design taps into our evolutionary predisposition to prefer environments that are ecologically rich, leveraging this innate connection to improve well-being and cognitive function. However, it contrasts with neuroarchitecture in that it prioritizes natural stimuli over neurological mechanisms, though both approaches share the common goal of improving user experiences through environmental design.

Neuroscience

Neuroscience is the multidisciplinary study of the nervous system, encompassing its structure, function, development, genetics, biochemistry, physiology, pharmacology, and pathology. This field integrates various scientific disciplines, including biology, psychology, and medicine, to explore how neural circuits and systems enable behavior, cognition, and emotion. Neuroscience's subfields, such as cognitive neuroscience, examine the neural substrates of mental processes, while other branches, like neuroarchitecture, apply neuroscientific principles to fields like architecture to understand how physical spaces influence neural and psychological responses. The insights gained from neuroscience inform a broad array of applications, from clinical interventions to the design of environments that promote mental and emotional well-being (Purves et al. 2018).

Neuroarchitecture

Neuroarchitecture is an interdisciplinary field that merges architectural theory with findings from neuroscience. This relatively new approach attempts to decode the complex relationship between human neurobiology and the environments we inhabit. In essence, neuroarchitecture seeks to design spaces that respond to the emotional and cognitive needs of occupants, leveraging empirical data to inform decisions that have traditionally been made based on intuition or aesthetic preference. For instance, neuroarchitects examine how the geometry of spaces, the presence of natural elements, and the quality of lighting can shape human experiences on a neurological level. Studies using EEG and fMRI have explored neural reactions to architectural stimuli, such as the effects of symmetrical versus asymmetrical designs, as well as how enclosed or open spaces impact brain activity related to pleasure and stress (Chatterjee, 2014). These insights inform a science-driven architectural practice, one that aligns design with the brain's inherent tendencies toward comfort, focus, or relaxation.

EEG: (Electroencephalography) A non-invasive method to record electrical activity of the brain using electrodes placed on the scalp.
fMRI: (Functional Magnetic Resonance Imaging) A neuroimaging technique that measures brain activity by detecting changes associated with blood flow.
EDA: (Electrodermal Activity) Measures the electrical conductance of the skin, which varies with its moisture level and is influenced by sweat gland activity.
PET Scans: (Positron Emission Tomography) Imaging technique that uses radioactive substances to visualize and measure metabolic processes in the body.

Mobile Brain/Body Imaging (MoBI)

An emerging neuroimaging technique that combines mobile EEG with motion capture to study brain activity in naturalistic settings while subjects are moving.

Resonance and Attunement

Resonance: The phenomenon where two systems, such as the brain and body, oscillate at the same frequency, leading to synchronization.
Attunement: The process of adjusting one's behavior, emotions, or physiological state to align with another person or environment.

Lived Body and Living Body

Lived Body: Refers to the subjective, experiential aspect of the body as perceived from within, emphasizing the personal, phenomenological experience of embodiment.
Living Body: Refers to the objective, physiological aspect of the body as observed from an external perspective, focusing on the biological and anatomical properties.

First-Person-Perspective and Third-Person-Perspective

First-Person-Perspective: A viewpoint where the narrator or protagonist is directly involved in the events being described, using "I" or "we."
Third-Person-Perspective: A viewpoint where the narrator is outside the events being described, using "he," "she," or "they."

Ecological Psychology

Ecological Psychology is a perspective within psychology that emphasizes the study of perception and action in natural, real-world settings. Unlike traditional psychology, which often examines cognitive processes in isolation, ecological psychology focuses on how individuals interact with their environments. It posits that human behavior cannot be understood without considering the context in which it occurs. This approach has significant implications for architecture, as it suggests that the design of spaces should be informed by the ways in which people naturally perceive and act within them.

The Principle of Affordance

A concept in ecological psychology that refers to the perceived and actual properties of an object or environment that determine how it can be used, such as a chair affording sitting.

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“

“The ships.”

“The ships what?”

“The ships are the eyes of the sea.”

Bartleboom was flabbergasted. He really had not thought of that.

“But there are hundreds of ships ...”

“The sea has hundreds of eyes. You can hardly expect it to get things done with only two ...”

”

From Ocean Sea by Alessandro Baricco