Faculdade de Design,
Tecnologia e Comunicação
Universidade Europeia

2025

IASMIM
RIBEIRO ASPAHAN

DESIGN FOR WELL-BEING:
Neuroscience Applied to Interior Design

Faculdade de Design, Tecnologia e Comunicação
Universidade Europeia

2025

IASMIM RIBEIRO ASPAHAN

DESIGN FOR WELL-BEING: Neuroscience Applied to Interior Design

Dissertation submitted to IADE - Faculty of Design, Technology, and Communication of the European University, to fulfill the requirements necessary to obtain the Master's degree in Product and Space Design, conducted under the scientific guidance of Dr. João Bernarda, Assistant Professor at IADE, and Dr. Fernando Martins, Assistant Professor at IADE.

Acknowledgements

I would like to express my deepest gratitude to my family for their unwavering support in my pursuit of knowledge beyond the borders of my home country. Thank you for encouraging me to follow my dreams and for standing by me, even from afar.

My heartfelt thanks also go to Daniel, my life partner, who continuously believes in me, offers his help when I need it most, and motivates me never to give up.

I am sincerely grateful to my professors for their commitment to sharing their knowledge, and in particular, to those who guided me throughout the development of this dissertation.

Keywords Neuroscience; Neuroarchitecture; Interior Design; Well-being; Evidence-Based Design.

Abstract

This dissertation examines how neuroscientific evidence can inform interior-design practice to enhance health, well-being and cognitive performance. Drawing on a critical review of neuroscience, environmental psychology and phenomenology, the study first clarifies the multisensory nature of spatial perception and the role of memory, culture and emotion in shaping experience. It then traces the historical shift from function-centred architecture to a human-centred, evidence-based paradigm, detailing the emergence of neuroarchitecture as an interdisciplinary field. Through a critical review of research on colour, form, texture, materials, lighting, biophilia, scale and proportion, it synthesises empirical findings with phenomenological perspectives to generate design guidelines. Through interior design project examples, it is possible to illustrate the practical application of these guidelines, while emphasising that they are guiding principles, not prescriptive rules. The dissertation concludes that integrating neuroscientific evidence with phenomenological insight enables designers to move beyond aesthetics, actively supporting emotional health, psychological comfort and cognitive performance.

TABLE OF CONTENTS

INTRODUCTION 3

CHAPTER 1.THE EMOTIONAL CONNECTION BETWEEN HUMAN BEINGS AND SPACES 5

CHAPTER 2.THE INFLUENCE OF COGNITIVE PROCESSES ON SPATIAL PERCEPTION 8

2.1 Perception and Subjectivity of Experience 10

2.2 Emotion and Memory in the Cognitive Process 13

2.3 The Cultural Context of Spatial Experience 15

CHAPTER 3. PHENOMENOLOGY: EXPLORING SENSORY EXPERIENCES IN INTERIOR DESIGN 20

3.1 Sensorial Phenomenon: Touch 21

3.2 The Gaze of Space: Sight 22

3.3 Memory Through Scent: Smell 23

3.4 The Sound of Space: Hearing 23

3.5 Flavours That Remain: Taste 24

CHAPTER 4. FUNCTION TO FEELING: THE EVOLUTION OF DESIGN FOR WELL-BEING 26

CHAPTER 5. DESIGNING FOR THE BRAIN: THE RISE OF NEUROARCHITECTURE 30

CHAPTER 6. BASIC FOUNDATIONS OF NEUROSCIENCE: UNDERSTANDING THE HUMAN BRAIN 35

CHAPTER 7. NEUROSCIENCE-INFORMED DESIGN: TRANSFORMING INTERIORS THROUGH NEUROSCIENCE 41

7.1 Colour 41

7.2 Form and Proportion 44

7.3 Textures and Materials 46

7.4 Lighting 49

7.5 Biophilia: Nature in he Built Environment 51

CHAPTER 8. NEUROSCIENCE IN ACTION: INTERIOR DESIGN PROJECT EXAMPLES 54

8.1 Two Union Square Lobby / NBBJ 58

8.2. The University Of Virginia, University Hospital Expansion / Perkins&Will 62

8.3 Pinterest Mexico City Office / Gensler 66

CHAPTER 9. SYNTHESIS AND PRACTICAL GUIDELINES FOR HUMAN-CENTERED DESIGN BASED ON NEUROSCIENCE 70

CONCLUSION 89

REFERENCES 92

INTRODUCTION

Since the dawn of civilization, human beings and their lifestyles have been represented by the spaces they inhabit, which have transformed over time according to the needs, habits, and cultural changes of society. The relationship between humans and the built environment is complex and multifaceted and extends beyond the need for shelter and comfort. It involves the way people relate, express themselves, and feel. Thus, beyond the practical and functional role, environments are capable of stimulating emotions and sensations in people, directly impacting their quality of life.

We do not always fully perceive the impact of environment on our emotions, nor do we completely understand the reasons behind these feelings. However, it is a fact that certain spaces attract us, while others cause discomfort, awakening the desire to leave quickly. Whether a place of rest or work, the activities carried out in these spaces should reflect more than their functionality or aesthetics, but the emotional stimuli they provoke. In this way, we can establish meaningful connections with the world we inhabit. Spaces can influence people's behavior, health, and well-being in different ways.

To understand how and why this happens, Neuroarchitecture has emerged, as a link between neuroscience and architecture with the goal of understanding how the environment we live in affects our perceptions, emotions, and our physical and mental health. Neuroarchitecture uses concepts from neuroscience to understand how the brain processes visual, sensory, and spatial information, and how these cognitive processes are affected by the built environment. Through applied neuroscience in interior design, it is possible to create spaces that stimulate cognitive functions and help reduce stress and anxiety, and design spaces that are more effective in fulfilling their objectives, whether they are workplaces, hospitals, schools, or homes.

By applying concepts of neuroscience, it is possible to understand how the brain reacts to sensory stimuli and, with this knowledge, create environments that provide positive experiences for users. The aim of this study is to deepen the understanding and analyse the principles of neuroarchitecture, starting from the idea that environments can transcend function and aesthetics, acting as catalysts for a more enriching human experience in interaction with the built environment.

The research was developed through a literature review, analysing scientific articles and works that address the themes of neuroarchitecture, design focused on well-being, and quality of life in spaces. Additionally, a set of interior design projects that incorporated neuroarchitectural principles in spatial design were analysed. Despite the recognised importance of this field of study, professionals still face challenges in assimilating, in a didactic way, the knowledge demonstrated by neuroscience.

Therefore, this dissertation proves relevant to the field of architecture and space design, not only because it recognizes the interconnection between the built environment and the cognitive and emotional functioning of people, but especially for the importance of systematic application in the practice of projects aimed at the well-being of the user.

CHAPTER 1. THE EMOTIONAL CONNECTION BETWEEN HUMAN BEINGS AND SPACES

Humans possess an intrinsic emotional connection to space, a phenomenon that is universally perceptible. Our memories of significant life events are often intertwined with the specific locations where they occurred, highlighting the profound role that space plays in our cognitive and emotional experiences. This recognition of 'affective spaces' illustrates how deeply places are embedded within our memories. Whether reflecting on the childhood home, the classrooms of our educational journey, or the settings of festive gatherings, these spaces are remembered not just as physical entities providing shelter or protection but as repositories of deeply personal and emotional significances. Ellard (2015) reflects on and questions whether the events that unfold around us in the places we inhabit, along with the memories formed within these spaces, influence our emotions and preferences towards the environments we will occupy in the future. In essence, there emerges a profound connection between our life experiences and memories, and the specific places in which those experiences took place.

In this context, Bachelard (2014) suggests that truly inhabited spaces carry the essence of what we perceive as 'home'. He argues that even the slightest form of shelter can awaken the human imagination, prompting it to create symbolic boundaries that evoke different sensations, such as protection, comfort, or, conversely, fear and vulnerability. The house, in this sense, becomes a space lived not only in its physical reality but also in its psychological and emotional dimensions. For Bachelard, the home is where memory and imagination intertwine, forming a deep emotional landscape in which past and present experiences coexist. As we inhabit new spaces, echoes of previous dwellings continue to shape our perceptions and emotional responses, revealing that our sense of home is less about chronology and more about affective bonds.

This leads us to consider that understanding the emotions evoked by objects and spaces is the key to achieving true well-being within the environments we inhabit. However, it must be recognised that no universal formula exists for such an understanding, as human perception is inherently subjective. Each individual's emotional responses are shaped by personal experiences, memories, and impressions accumulated throughout life, and these experiences are, in turn, intimately connected to the spaces where they unfold.

In this light, De Botton (2006) offers a pertinent reflection of how despite the significant expressive potential of objects and buildings, there remains a widespread tendency to overlook their emotional and symbolic dimensions, with discussions often confined to historical contexts and stylistic classifications rather than deeper metaphorical or evocative meanings. De Botton imagines the value of a comprehensive dictionary that would systematically correlate materials, forms, and dimensions with specific emotions and ideas, thus enabling a more conscious reading of our built environment. Such a resource would acknowledge the subtle but profound influence that even minor alterations, such as a slight curvature in a lintel, can have on our emotional perception of a space, much like a single word can transform the meaning of a poem.

Yet De Botton ultimately recognises that no manual, however detailed, could fully capture the reasons why certain buildings move us. The emotional resonance of architecture, he argues, extends beyond form and materiality to embody deeper symbolic values, qualities such as kindness, subtlety, strength, and honesty, which reflect our individual concept of a good life. In De Botton view, spaces do not merely function as physical shelters but become vessels of memory, imagination, emotion, and aspiration, continuously shaped by the singular life journeys of individuals.

Building upon these perspectives, Pallasmaa et al. (2015) highlights the profound interrelationship between physical space, behaviour, and mental states. He asserts that in designing environments, architects are simultaneously shaping emotional experiences and cognitive responses, operating as much within the human brain and nervous system as within the material world. Drawing upon research in psychology and neuroscience, Pallasmaa explains that environments not only influence but also induce lasting structural changes in the brain, thereby altering behaviour and emotional patterns. Architectural spaces, therefore, are not mere passive stages for action; they actively choreograph moods, stimulate emotions, and frame our perception of everyday life. He distinguishes between two types of imagination: a formal imagination concerned with geometry and form, and an empathic imagination that evokes multi-sensory, lived experiences. It is through this empathic engagement that architecture resonates with the human condition, mediating the atmosphere of spaces and deeply influencing our existential experience of the world.

However, this understanding of the intrinsic relationship between our mental and emotional states has been extensively studied by Damasio (1996). In Descartes' Error, he demonstrates that emotions are inseparable from cognitive functions and bodily processes, playing a critical role in decision-making and rational thought. This perspective is particularly significant when considering how interior spaces can evoke emotional responses through sensory stimuli, subtly yet profoundly influencing behaviour, well-being, and perception.

Ellard (2015) highlights that architecture and spatial design have historically been employed as powerful tools for evoking specific emotional responses, long before any scientific understanding of such phenomena existed. The emotional power of architecture is neither incidental nor recent; rather, it has been a deliberate tool for influencing human perception and behaviour across centuries. Grand religious buildings, for example, with their soaring ceilings, intricate paintings, and colourful stained-glass windows, were deliberately designed to inspire awe and a sense of connection with the divine.

Yet while historical builders relied on intuition and symbolism to provoke feelings such as awe or submission, contemporary designers can operate with the backing of scientific knowledge capable of dissecting the very fabric of emotional and cognitive experience. Today, spatial design is evolving beyond an art based solely on aesthetic or cultural assumptions, increasingly becoming an applied science in which insights from sociology, psychology, cognitive science, and neuroscience converge, guided by measurable data on how environments influence the human body and mind.

CHAPTER 2. THE INFLUENCE OF COGNITIVE PROCESSES ON SPATIAL PERCEPTION

The spaces we inhabit are not passive backdrops to our lives; they actively shape how we feel, think, and behave. It is therefore essential to understand the cognitive foundations of this relationship by examining how processes such as attention, perception, memory, and pattern recognition influence our interaction with the built environment. According to Villarouco et al. (2021), cognitive psychology theory exerts a strong influence on neuroscience by providing fundamental experimental foundations for defining key dimensions of mental functioning, such as perception, learning, attention, memory, consciousness, and emotion. The cognitive process begins with our senses, which continuously gather information from the environment. Among cognitive abilities, attention plays a crucial role by filtering the vast amount of sensory input we receive. It acts as a selective gateway, determining which stimuli will be processed further.

Attention can be categorised as either focused, when concentration is directed towards a single source of information while ignoring distractions, or divided, when attention shifts between two or more tasks. However, although divided attention allows for multitasking, it comes at the cost of increased cognitive effort and decreased performance, often resulting in reduced quality and efficiency. Another distinction exists between external attention, which focuses on sensory input from the surrounding environment, and internal attention, which relates to the selection and processing of internal information such as memories, imagination, or reasoning. Nevertheless, while attention is responsible for filtering sensory information, it is perception that organises and interprets these stimuli based on patterns previously learned by the brain (Villarouco et al., 2021).

The prefrontal cortex plays a critical role in this process, employing inhibitory control to suppress irrelevant information and focus mental resources on the task at hand. Perception does not merely reflect the external world as it is; rather, it is shaped by learning and memory. It involves recognising familiar patterns and filling in gaps, resulting in phenomena such as perceptual constancy, where the brain maintains stable perceptions despite changing environmental conditions. This includes constancy of shape, size, and colour, enabling us to recognise faces and objects under varying lighting and perspectives. For example, colour constancy allows us to perceive an object as having the same colour even when lighting conditions change. This chromatic adaptation conserves cognitive energy and facilitates object and person recognition (Villarouco et al., 2021).

Since pattern recognition is central to cognitive processes, phenomena such as perceptual constancy explain how we can identify forms, sizes, and colours even when environmental stimuli vary. It is due to this mechanism that we can recognise a person despite changes in superficial characteristics like clothing or hairstyle. These aspects of perception are valuable tools for architects, who leverage knowledge of colour, light, and perspective to design spaces that enhance users' perceptual experiences.

Assem et al. (2023) highlight that perception and cognition are fundamental to understanding the architectural environment. Perception involves the ability to see, hear, and interpret the surroundings through cognitive processes in the brain. Cognition, by contrast, refers to the mental mechanisms by which information from the environment is acquired, processed through thought and experience, and subsequently used to form opinions and make decisions.

The sensory readings occurring in the human mind, shaped by individual experiences, perceptions, and preferences, follow a cognitive flow involving stages such as perception (at the sensory level), selection (through memory processes), and attribution of meaning (based on logic and reasoning) (Kanashiro, 2003).

The architecture of any environment provides a range of stimuli that affect human emotions by activating specific brain areas, triggering cognitive processes, and even promoting neurogenesis over time. This neurological activation can impact decision-making and influence behaviour. For instance, pleasant environments have been shown to stimulate the brain's left frontal areas associated with spatial navigation. Conversely, various environmental stimuli can provoke physiological changes, such as fluctuations in blood pressure, even before we become consciously aware of them (Assem et al., 2023).

In *Architecture and Empathy* (Pallasmaa et al., 2015), neuroscientist Vittorio Gallese argues that cognitive neuroscience should complement a humanistic approach, contributing to a broader understanding that transcends a reductionist view of the brain in isolation. He emphasises the contribution of cognitive neuroscience to the comprehension of the aesthetic and symbolic dimensions of human existence, highlighting how interdisciplinary collaboration between neuroscience, philosophy, art, aesthetics, and architecture can deepen our understanding of the subjective and complex nature of human and cultural experience, particularly in relation to architecture's capacity to evoke emotions.

Cognitive processes thus play a central role in spatial perception, underpinning our ability to interpret and engage with the environment. Beyond helping us understand how we perceive and navigate the world, the study of these processes also informs the development of new technologies and design strategies aimed at enhancing spatial experience.

2.1 PERCEPTION AND SUBJECTIVITY OF EXPERIENCE

As previously established, perception functions as the "gateway" to cognition; before any cognitive processing of information can occur, it must first be perceived. However, it is important to emphasise that perception is inherently subjective, as it is influenced by individual experiences, expectations, memory, and other cognitive processes.

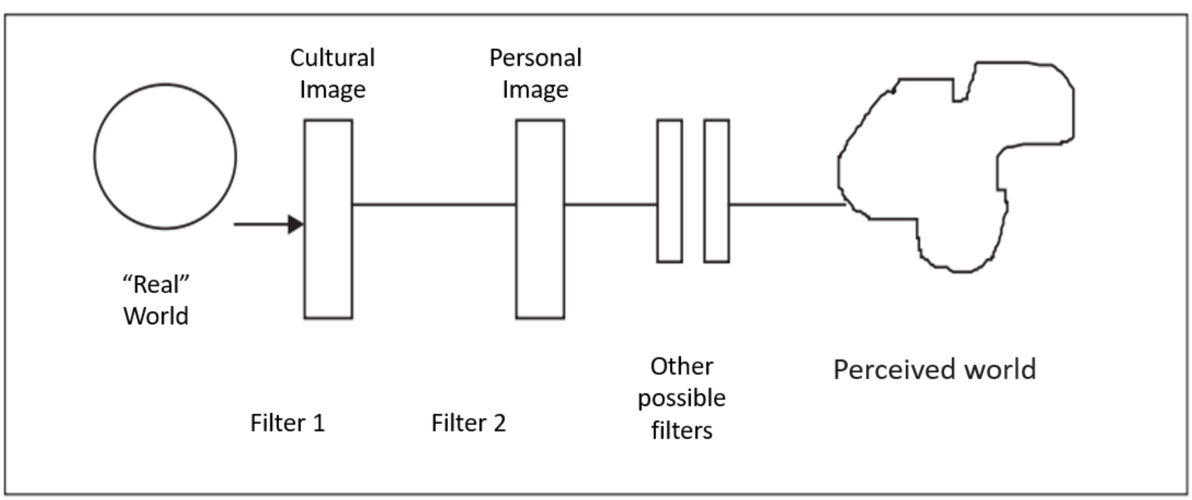
A significant aspect of this process involves the brain filling in gaps and relying on familiar patterns, effectively disregarding variable details within those patterns. Repeated experiences determine what is retained in memory, while variations are often filtered out. In this regard, Villarouco et al. (2021) highlight that we do not perceive the world exactly as it is, but rather as we have learned to see it.

Kanashiro (2003) further distinguishes between perception and cognition, noting that perception is driven by the physical properties and stimuli of the environment, whereas cognition depends on the knowledge, awareness, and symbolic interpretations attached to these stimuli. Figure 1 illustrates how the perceived environment can be reconstructed through external stimuli, while individual filters, such as culture, ideals, and personal meanings, shape different representations of the "real world."

Ultimately, the world we perceive is not the world as it is, but the world as it is filtered through the unique lens of our personal experiences, memories, and expectations. Understanding perception as a multisensory and subjective process is fundamental when investigating how individuals experience and interact with the environment. Far from being a neutral or uniform phenomenon, perception is shaped by a complex interplay of sensory stimuli, cognitive functions, emotional states, and cultural backgrounds that varies all the time. It reveals how deeply our experience of space is tied not only to the physical world but also to memory, emotion, and personal history.

Figure 1

Perception Scheme



Perception of the world around us is inherently a multisensory process, as our daily lives are shaped by the continuous interaction between the built environment and our senses, particularly vision, smell, hearing, and touch. Vision provides more information than any other sense, allowing us to perceive spatial details such as distance, texture, light, and colour, elements that are fundamental to understanding the built environment. Vision also has the ability to evoke memories and emotions. As we move through spaces, visual perception offers two perspectives: the recognition of what is already familiar and the assimilation of new information, allowing us to perceive and feel spaces kinetically, positioning ourselves within them and grasping the organisation of visual fields (Kanashiro, 2003).

Smell, although often overlooked in discussions about space, plays a crucial role. It can reinforce or contradict visual impressions: while vision may identify a space as unpleasant, olfactory cues can intensify that perception. Kanashiro (2003) emphasises that odours forge a more intimate and emotional connection with a place than sight alone can provide. In comparison, hearing offers less spatial precision than vision or smell; while we can identify the source of sounds, gauging their exact distance is more challenging. Touch, on the other hand, allows us to experience space through physical interaction. Through touch, we feel the air, the ground beneath our feet, and the textures of materials, distinguishing between surfaces, volumes, and sensations that our bodies encounter (idem, 2003).

Kanashiro (2003) argues that in the creation of urban spaces, visual considerations have historically dominated, often at the expense of other sensory experiences, particularly touch. The predominance of one sense over others can limit our overall perception of the environment, affecting the way we relate to and experience cities—spaces that often suppress a full multisensory engagement with the urban fabric.

According to Bestetti (2014), perception is how our body translates environmental stimuli into behavioural patterns, filtered through an individual's dominant senses. Thus, perception is inherently subjective, shaped by personal experiences, cultural values, references, and the environment in which we live. Different individuals may interpret the same reality in vastly different ways.

Perception is also profoundly connected to our emotional and affective states, which act as filters, altering the way we experience the world. Sarah Robinson reflects on how we are intrinsically tied to the biological, emotional, and sociocultural limitations and opportunities of our existence, arguing that our interactions with the environment continuously shape who we are (Pallasmaa et al., 2015).

It is crucial to recognise that spatial awareness is not a passive act of absorbing information; it is actively constructed by the mind and shaped by past experiences, expectations, and cultural background. For instance, a space perceived as warm and welcoming by one person may feel restrictive or oppressive to another, depending on their personal histories.

What we see and how we interpret space is subjective and may not correspond to reality as it objectively exists. Since ancient times, philosophers have questioned the nature of reality and human perception. This subjectivity is vividly illustrated in Plato’s "Allegory of the Cave," where human perception is portrayed as mere shadows of the true reality. Just as the prisoners in the cave mistake shadows for reality, humans tend to rely on immediate sensory perception without questioning its deeper truth, perceptions that are profoundly influenced by culture, memory, education, and prior experience.

Kanashiro (2003) stresses that the concept of "place" should be understood as a dynamic relationship between lived spatial experiences, both individual and collective, transforming abstract geometric spaces into meaningful places through everyday experience. Sensory perception of the city extends beyond the visual, incorporating sounds, smells, and textures that contribute to the formation of memories and emotions associated with space. Therefore, Kanashiro reflects on the importance of considering invisible aspects, those captured by the senses and often carrying greater emotional intensity, as crucial components in the planning of spaces and cities.

The variation in sensory experiences across different groups, cultures, and historical periods further highlights the importance of acknowledging subjectivity in environmental perception. Environmental problems are fundamentally human in nature, shaped by motivation, values, and attitudes towards the environment (Kanashiro, 2003). By seeking a deeper understanding of the processes of perception, cognition, and emotion, neuroarchitecture aspires to create spaces that foster meaningful connections between individuals and their environments. Designs that embrace multisensory perception and the subjectivity of human experience are thus more likely to succeed in creating spaces that are truly aligned with the needs and well-being of their users.

> Perception is a way in which human beings keep track of our relationship to the world 30, directing our experiences towards things, to uncover and understand both the world and our physical environment. Architecture has the ability to evoke such responses from us, propelling us to think and understand the relationships created with our surroundings through our experiences. (Ruiz-Arellano, 2015, p. 16)

2.2 EMOTION AND MEMORY IN THE COGNITIVE PROCESS

If perception offers the first gateway through which we experience the world, consciousness and memory deepen this relationship, weaving together sensation, emotion, and identity. These interconnected processes not only define how we interpret and engage with the built environment but also influence the ways in which spaces are remembered and emotionally anchored within our identities. By examining the cognitive and neurological foundations of consciousness and memory, a more comprehensive view emerges of how spaces can evoke lasting emotional connections, shaping both individual experiences and collective memories.

As previously established, perception can be understood as the process by which the brain makes sense of incoming stimuli. However, Villarouco et al. (2021) stresses the importance of distinguishing between perception and consciousness, noting that perceiving does not necessarily equate to understanding, as only a very small fraction of processed information reaches the level of conscious awareness. In neuroscience, consciousness is often defined as the degree of the brain's responsiveness to environmental stimuli, ranging from states of coma to full alertness, such as the waking state. This conscious state allows for an adequate quality of attention and the proper functioning of cognitive processes.

Moreover, scientific literature examines the state of conscious perception that generates the sensation of "self," known as phenomenal consciousness. This form of consciousness involves the perception of both internal and external stimuli, encompassing thoughts, memories, imagination, self-awareness, and behavioural self-regulation. It is intimately linked to our ability to rationalise experiences and create subjective interpretations of reality. Consciousness is attributed with functions such as environmental awareness, social communication, and the understanding of others' intentions, commonly referred to as social cognition. This form of consciousness is crucial for behavioural regulation, enabling reflection on lived experiences both in the moment and retrospectively, as well as integrating various types of information (Villarouco et al., 2021).

The regulation of emotions is intrinsically connected to consciousness, and consciousness, in turn, is invariably influenced by emotional states. Philosopher John Dewey had already emphasised the centrality of emotion in cognitive processes long before this was confirmed by neuroscience. The limbic system, known as the brain's emotional centre, demonstrates its influence over most mental processes, illustrating how emotion and cognition are deeply interwoven aspects of human behaviour. They are the outcome of activities within different brain regions, which, although not strictly emotional or cognitive, significantly affect behaviour depending on the neural context in which they operate (Pallasmaa et al., 2015).

Within this perspective, neuroscience addresses the ongoing debate regarding conscious control over action. Villarouco et al. (2021) notes that neuroimaging studies suggest that many significant decisions are processed prior to conscious awareness, with emotions playing a key role in modulating cognitive capabilities such as attention, perception, memory, and self-control.

Emotional states of high motivational intensity are associated with a narrowing of attention, while low-intensity emotional states tend to broaden the attentional field. Thus, intense emotions, such as passion, fear, or euphoria, are more likely to dominate memory formation, overshadowing other stimuli present in the environment. This illustrates how emotional biases profoundly shape both perception and the memories we construct from our experiences (idem., 2021).

LaBar and Cabeza (2006) reinforce the idea that emotionally charged events are remembered more vividly. Emotional processing, particularly involving the limbic system and the amygdala, plays a crucial role in consolidating memory during the encoding of emotionally significant information. The amygdala acts as a key mediator of emotional learning and supports memory processes in other brain regions, including the hippocampus and the prefrontal cortex. Understanding the impact of emotion on memory has significant implications for mental health conditions such as post-traumatic stress disorder (PTSD) and depression, where emotional memories may become distorted or disproportionately salient.

Memory operates bidirectionally within this context: it is shaped by emotions that influence what we attend to and perceive, and it, in turn, affects how we recognise and relate to elements in our environment. This dynamic relationship between memory and emotion largely determines our conscious awareness across different contexts. It is, therefore, inevitable that memories undergo alteration over time. Every new experience has the potential to evoke and reshape existing memories; when recalled, memories are reconfigured rather than retrieved unchanged. Memories form the foundation of individual identity and perspective, and they are continuously redefined through new experiences (Villarouco et al., 2021).

According to Ruiz-Arellano (2015), memory differs fundamentally from perception, as it relates to events and stimuli that no longer belong to the present moment. It is through memory that we construct our sense of self and our position within the world. Memory allows us to accumulate knowledge and to revisit faces, places, and experiences; with every new encounter, consciously or unconsciously, we access memory to make sense of our surroundings, interpret and give meaning to what we encounter.

Advances in neuroscience have identified the hippocampus as the brain region responsible for analysing and determining which information is consolidated into long-term memory. Specifically, architectural experiences are associated with the parahippocampal place area (PPA), which recognises spatial scenes to create a multisensory experience that supports long-term memory formation. Memory processing can be divided into three stages: encoding, storage, and retrieval. Encoding involves sensory perception and focused attention, intensifying the experience and increasing the likelihood of its consolidation. Storage filters out excess sensory information, allowing significant long-term memories to persist over a lifetime. Retrieval involves the reactivation of neural patterns, enabling the creative reimagining of past experiences (Ruiz-Arellano, 2015).

Architecture influences memory formation by providing enriched environmental stimuli that promote neurogenesis, particularly within the hippocampus. Thus, recalling architecture is not merely about remembering physical spaces, but also about evoking the emotions and feelings associated with the experiences lived within them, echoing the reflections of Peter Zumthor as cited by Ruiz-Arellano (2015).

> There was a time when I experienced architecture without thinking about it. Sometimes I can almost feel a particular door handle in my hand, a piece of metal shaped like the back of a spoon. I used to take hold of it when I went into my aunt's garden. That door handle still seems to me like a special sign of entry into a world of different moods and smells. I remember the sound of the gravel under my feet, the soft gleam of the waxed oak staircase, I can hear the heavy front door closing behind me as I walk along the dark corridor and enter the kitchen, the only really brightly lit room in the house.
>
> [...] Memories like these contain the deepest architectural experience that I know. They are the reservoirs of the architectural atmospheres and images which I explore in my work as an architect. (Zumthor, as cited in Ruiz-Arellano, 2015, p. 20)

2.3 THE CULTURAL CONTEXT OF SPATIAL EXPERIENCE

If our individual perceptions and memories are also shaped by sensory experiences, it is through culture that these experiences are given collective meaning. As we engage with the built environment, we do so not only through our senses but also through the values, beliefs, and histories that shape our understanding of space. Recognising the influence of the sociocultural context invites a deeper reflection on how spaces embodies shared identities and how our environments, in turn, continue to mold both personal and collective consciousness.

As previously discussed, the sociocultural environment has a profound impact on human perception and interaction with space, acting as a filter of reality that shapes how the world is interpreted. Values, beliefs and cultural practices guide the design and use of places as well as the meanings ascribed to them, changing how they are perceived and understood. Rosendahl and Corrêa (2013) argue that a landscape is more than a material expression of culture; it is a repository of shared meanings and interpretations. Geographic space is therefore both produced by cultural processes and actively participates in their ongoing transformation.

Culture frames habits and values, shaping the spatial configurations of different regions and historical periods. In some societies domestic layouts privilege family privacy, whereas in others communal areas for social interaction dominate. We can observe how architecture and design occupy central roles in many countries and cultures. Scandinavian design, originating from northern European countries such as Sweden, Denmark, Norway, and Finland, illustrates this dynamic clearly. Although celebrated globally for its lucidity and functionality, it is deeply grounded in the everyday philosophy of the Scandinavian peoples, embodying values such as simplicity, integrity and utilitarian efficiency (Villarouco et al., 2021).

Scandinavian design exemplifies a language that emerges from, and remains embedded within, a specific cultural context; its principles may not transfer seamlessly to regions where habits, climate, social structures and values differ markedly. This reality underscores the need to approach design not merely as an aesthetic exercise but as a means of aligning built environments with the aspirations, needs and temporal rhythms of particular communities. To achieve this, it is essential that cultural dimensions and their underlying roots are fully understood and thoughtfully integrated into the design process.

In *Architecture and Empathy* (Pallasmaa et al., 2015), architect Harry Francis Mallgrave reflects that architectural history is best read as a history of ideas rather than a simple chronology of buildings or stylistic change. Accordingly, those periods when the arts were most heavily influenced by stylistic transformations were often the same periods when architectural theory was most profoundly shaped by cultural ideas. As Villarouco et al. (2021) observe, "since architecture functions as a representation of a society in a given place and at a specific time, the built environment begins to represent this notion of collective self, transmitting the thinking of an era" (p. 112).

Mallgrave further highlights the major shifts in understanding the relationship between genes and culture, particularly following the technological advances that enabled the sequencing of DNA. The biological theory of "niche construction" exemplifies this interconnected thinking, proposing that the changes we make to our physical and cultural environments, in turn, affect our genetic and behavioural structures. This perspective reinforces the view that our brains, bodies, and environments are interactive, dynamic systems intricately linked on multiple levels (Pallasmaa et al., 2015).

Norberg-Schulz (1980) reminds us that the *genius loci*—the spirit of place—resides in the stylistic choices through which a community narrates its collective identity. In the historic centres of Portugal, tiled façades in blue-and-white azulejo and wrought-iron balconies do more than ornament the urban fabric. They embed memories of maritime expansion and Catholic devotion within everyday spatial experience. As can be observed in Figure 2, such motifs invest streets and squares with a symbolic depth that exceeds mere visual appeal, anchouring contemporary life in a recognisable cultural continuum.

Figure 2

Portuguese Architecture

Bachelard's notion of the poetics of space further elucidates how materiality can evoke affective resonance (Bachelard, 2014). In the Japanese tea-house (chashitsu), where tatami modules, shōji screens and unadorned wood surfaces create an atmosphere of hushed intimacy. The deliberate compression of scale, the filtered daylight and the ritual sequence of approach invite a heightened awareness of scent, sound and texture, turning architectural restraint into a contemplative experience. In this setting, material simplicity elicits reverie and anchors collective memory in the seasonal cycles of nature, demonstrating how spatial minimalism can evoke profound emotional resonance.

Figure 3

Japanese tea-house (chashitsu)

Vernacular construction in Brazil's semi-arid north-east offers a contrasting yet complementary illustration. Employing local earth, wood and communal labour, taipa dwellings respond pragmatically to climate while reaffirming traditions of mutual aid. Rapoport (1990) argues that such environments materialise social values as much as they meet physical needs. The continuity of these building practices, even today, is anchored in shared knowledge and seasonal rhythms, illustrating how cultural identity is sustained, adapted and transmitted through the very act of constructing and inhabiting space.

Figure 4

Contemporary Taipa House in Brazil

Thus, culture emerges as a powerful force in shaping how we engage with the world around us, including how we relate to space and the habits associated with it. As Pallasmaa et al. (2015) reflects, " Just as we change the aspects of our cultural context, so does our ever-changing culture alter our cognitive structures” (p. 28).

CHAPTER 3. PHENOMENOLOGY: EXPLORING SENSORY EXPERIENCES IN INTERIOR DESIGN

A comprehensive understanding of spatial experience demands attention that goes beyond material and functional attributes. Space is more than a setting to be occupied; it is felt, remembered and lived. Resonating through body and senses, it becomes entwined with emotional and existential life. In probing this depth, phenomenology offers a potent framework for examining how built settings speak to the essence of being.

Phenomenology, a term derived from the Greek words *phainesthai* (to appear) and *logos* (study), is the discipline concerned with the study of phenomena, specifically, how experiences arise through our perception and consciousness. According to Özçam (2022), the perception of space as a sensory and embodied experience gained prominence through the phenomenological approach that emerged in the early 20th century. From the 1980s onwards, scholarship increasingly conceived perception as an active, multisensory and context-embedded process rather than the passive intake of stimuli. This shift reflects a broader move away from viewing perception as a passive reception of stimuli, toward an understanding of it as a lived, meaning-making process embedded in context and consciousness.

Within this perspective, phenomenology focuses on the conditions under which things appear to us through lived experience. The world emerges not as an objective, detached entity but as a web of references shaped by perceptual engagement. We participate in that world, perpetually influencing and being influenced by our surroundings.

Drawing on the ideas of philosopher Merleau-Ponty, Özçam emphasises that perception constitutes the primary avenue through which humans apprehend reality. The body acts as an agent of knowing; spatial experience therefore gains meaning through embodied presence. In consequence, space cannot be reduced to neutral geometry, it is always interpreted, felt and remembered in dialogue with the body, memory and emotion.

Garcia (2021) highlights Husserl's insistence that knowledge formation is inseparable from subjective vantage. Phenomena refer not to events themselves but to their appearance within consciousness. Accordingly, a phenomenologically informed space acquires significance through sensory engagement. For Merleau-Ponty, that engagement reaches completion only when body and environment enter into reciprocal dialogue.

Pallasmaa (1994), in *The Architecture of the Seven Senses*, extends this subject-centred stance, arguing that the timeless task of design is to fashion existential metaphors that materialise and structure human life. Throughout history, buildings and cities have preserved cultural values, lifestyles and socio-political currents, anchoring collective memory and identity.

Garcia (2021) advances the discussion by stressing the “in-between”, the medium through which we relate to the world. In spatial design, every element should carry purpose and meaning; multisensory stimulation reinforces bonds between user and environment, satisfying physical as well as emotional needs. Embodied memory, in turn, shapes how we recall places: our dwelling becomes integral to identity, as inseparable from the self as the body itself (Pallasmaa, 1994).

Building upon the philosophical insights of Emanuele Coccia, Garcia (2021) observes that existence depends on our capacity to see, hear, touch and taste the world. Sensation grants access to images and meaning; without it, life would collapse into mere rule-following. In this view, human beings inhabit a continuous sensory field that sustains and shapes being.

Hence, spatial design that embraces phenomenological principles must acknowledge the hierarchy and interplay of the senses. Garcia (2021) cites research indicating that humans retain approximately 35 % of what they smell, 15 % of what they taste, 5 % of what they see and only 2 % of what they hear or touch. Vision’s cultural dominance may lead to visual saturation, hindering deeper mnemonic formation; during intense emotion, notes Pallasmaa (2012), we instinctively close our eyes, allowing tactile and olfactory impressions to surface with greater clarity.

A concise synthesis of the senses and their architectural implications therefore proves indispensable. Spatial experience derives not solely from what we see but from the full spectrum of embodied engagement with place.

3.1 SENSORIAL PHENOMENON: TOUCH

Touch is a deeply significant sense within interior design, expressed through elements such as rugs, curtains, and textured surfaces that invite contact and evoke feelings of comfort and warmth. As Garcia (2021) observes, architects such as Hundertwasser designed consciously for the senses, creating rich tactile experiences that foster a deeper connection between people and the material world. According to Pallasmaa (2012), the skin, as the body’s largest sensory organ, perceives texture, weight, density, and temperature. Through touch, we also sense the ambient qualities of a space, such as the cooling shade of a tree or the warmth of direct sunlight. The tactile sense connects us to memory, particularly to childhood experiences, re-establishing a sensory link to tradition, time, and the past.

As previously mentioned, our sensory perception is often dominated by visual stimuli. However, there are ways to lessen this dominance and enhance the role of touch. By reducing light and introducing areas of shadow, one can soften visual clarity, encouraging the imagination and deepening the tactile experience (Pallasmaa, 2012).

Ruiz-Arellano (2015) references the ideas of philosopher René Descartes, who considered touch to be more reliable than sight. While other senses tend to deteriorate with age, touch remains a vital tool for learning, protection, and emotional connection with the surrounding environment. It enables us to navigate space, as it is both the sense that perceives what is being touched and the medium through which the body itself is felt. Touch grants us the ability to infer, interpret, and attribute meaning to experience, reinforcing its essential role in memory and learning.

But the eye also touches; the gaze implies an unconscious bodily mimesis, identification. Perhaps, we should think of touch as the unconscious vision. Our gaze strokes distant surfaces, contours and edges, as the unconscious tactile sensation determines the agreeableness or unpleasantness of the experience. The distant and the near are experiences with the same intensity. The great architecture offers shapes and surfaces molded for the pleasure touch of the eye (Pallasmaa, 1994, p. 45)

3.2 THE GAZE OF SPACE: SIGHT

According to Villarouco (2021), sight is the most consciously used sense in understanding the space around us. Human vision functions by detecting light reflected from objects, allowing us to identify shapes, colours, and spatial relationships. The eye itself is a sophisticated sensory organ: light passes through the cornea, which both protects the eye and helps focus the image. The iris regulates the size of the pupil, while the lens adjusts focus and directs light onto the retina. As noted by Garcia (2021), the perception of shape and colour is rapid and highly efficient for the human eye. However, colour is more than a physical phenomenon. While it stems from measurable wavelengths of light, the perception of colour varies significantly across individuals, and even across species, revealing its dual nature, simultaneously physiological and subjective. Colour perception, therefore, involves both sensory mechanisms and psychological interpretation.

Light plays a central role in shaping perception, actively influencing how space is seen and felt. Together, light and colour shape impressions of form, surface, texture, and atmosphere. (Ruiz-Arellano, 2015). Despite the richness of visual perception, human vision functions in two dimensions, with the brain responsible for constructing the illusion of three-dimensional space. This creates certain limitations in our ability to perceive depth and distance accurately. To assist in spatial understanding, the retina detects various perceptual cues, including overlap, aerial perspective, shading, height in the visual field, linear perspective, texture gradients, and relative size. These cues help the brain estimate dimensions and relationships within a space, based on previously learned references (Villarouco et al., 2021).

However, Villarouco (2021) also observes that these cues can occasionally generate contradictory information, giving rise to optical illusions where perception diverges from physical reality. In architectural and interior design, such perceptual effects are frequently employed to produce specific atmospheres; for example, to amplify the sense of spaciousness or introduce dynamism through the calculated arrangement of objects, surfaces and lighting.

3.3 MEMORY THROUGH SCENT: SMELL

Although often overlooked, smell is a crucial element in shaping memory and establishing the atmosphere of a space. Every environment carries its own scent, capable of evoking emotions and triggering vivid recollections. Designing with olfactory experience in mind can become a powerful tool for fostering an emotional connection between the user and the environment.

Spence (2020) reflects on how design strategies involving smell are frequently limited to the elimination of unpleasant odours. However, it is important to recognise that each individual has personal scent preferences that can deeply influence their experience of a place. Pallasmaa (1994) notes that the strongest memory of a space is often its scent; he recalls the smell of his grandfather’s house more vividly than its appearance. “A particular smell may make us secretly re-enter a space that has been completely erased from the retinal memory; the nostrils project a forgotten image and we are enticed to enter a vivid daydream” (Pallasmaa, 1994, p. 44).

In this sense, Pallasmaa (1994) highlights the profound emotional power of scent. Smells can awaken long-forgotten memories and transport us to specific moments and places in our lives with remarkable clarity. The interplay between smell, memory, and space is both complex and intimate, revealing the essential role of the senses in shaping not just spatial perception but also enduring emotional connections with place.

3.4 THE SOUND OF SPACE: HEARING

Every space carries its own soundscape, shaped by form, volume, and materiality. Architect and professor Peter Zumthor, in his book *Atmospheres: Architectural Environments Surrounding Objects*, described interiors as vast instruments that collect, amplify, and transmit sound. Even in total silence and emptiness, he observed, each space possesses its own distinct sound (Garcia, 2021).

Pallasmaa (1994) underscores the evocative and immersive quality of auditory experience in architecture. Acoustics can dramatically influence our emotional response to a space. A bare, unfurnished room may produce a harsh, echoing resonance, whereas a lived-in home absorbs and reflects sound in a way that conveys softness, warmth, and familiarity.

Each environment generates a distinct auditory character, evoking sensations ranging from intimacy to grandeur, welcome to rejection, hospitality to hostility. Hearing fosters a sense of connection, with both the space and those within it. As Pallasmaa (1994) observes, music heard in a concert hall becomes a collective experience, momentarily uniting the audience through shared emotion and atmosphere. In this way, sound transcends its physical attributes, serving as a medium of both social and spatial cohesion.

> We stare alone at the suspense of the circus, but the burst of applause after the relaxation of suspense unites us to the crowd. The sound of church bell through the streets males us aware of our citizenship. The echo of steps on a paved street has an emotional charge because the sound bouncing off the surrounding walls put us is direct interaction with space; the sound measures space and makes its scale comprehensible. We stroke the edges of the space with our ears. (Pallasmaa, 1994, p. 43)

3.5 FLAVOURS THAT REMAIN: TASTE

Although less directly associated with interior design, taste remains an integral part of our embodied experience in the world and, like the other senses, plays a role in the creation of memory. As Garcia (2021) observes, tasting is more than a physiological response; it is a deeply emotional and culturally embedded act that grounds us in time and place.

In many cultures, the kitchen is the heart of the home and concentrates a significant part of this experience of being in the world through taste, which transforms into memory: food, fruits, herbs, vapours, etc. This relationship is one of the most primary and necessary in the individual’s connection to life, as it is tied to survival, but also to pleasure, a habit that connects us to life and the present. (Garcia, 2021)

As explored throughout this chapter, there is a profound connection between sensory experience, memory, and emotion. The senses emerge not as passive channels of perception, but as active agents in the construction of spatial experience. Vision, while culturally dominant, offers only a fragment of our interaction with the environment. Smell and touch, often overlooked in contemporary spatial design, hold a unique emotional immediacy, anchoring memories and evoking atmospheres with remarkable depth. Sound, though harder to locate with precision, contributes to the spatial narrative by shaping rhythm and tone. Taste, though rarely engaged in architectural discourse, forms part of our embodied presence in specific cultural and domestic rituals. Together, these senses form a complex, integrated system through which space is inhabited, remembered, and emotionally internalised. Recognising the full sensory dimension of space is thus essential for any design approach that seeks to resonate with the lived human experience. Our experiences are inextricably linked to our senses, allowing us not only to recall the physical aspects of spaces but, more importantly, the emotions lived within them. Özçam reinforces this idea, reflecting on how deeply embodied and emotional our connection with spaces can be:

> However, architecture is a concept that can be perceived and explained by multiple senses; it connects people mentally, perceptually, and physically while also taking a place in their memory, emotional world and life and giving the experience of existence. Parallel to this, architecture and interior design are disciplines for planning livable atmospheres where practical, aesthetic, symbolic functions in addition to physical and sensory properties of materials are prioritized. Consciously or unconsciously, our body is in constant dialogue with the environment, and with this awareness, the designer should be able to make conscious decisions regarding the use and effects of elements such as the quality of the space, textural features, juxtapositions, contrasts, light, color, and materials. (Özçam, 2022, p. 12-13)

CHAPTER 4. FUNCTION TO FEELING: THE EVOLUTION OF DESIGN FOR WELL-BEING

The relationship between human beings and the spaces they inhabit has long been the subject of reflection and research in fields such as philosophy, psychology, architecture, and various other disciplines within the social and human sciences. Insights from these fields have profoundly shaped our understanding of this complex interaction. As early as the 5th century BC, Hippocrates (c. 460–370 BC), regarded as the “father of medicine”, stated that the brain interprets the external world, governs consciousness, and serves as the centre of intelligence and will, asserting that the entire body was governed by it (Breitenfeld, Jurasic, & Breitenfeld, 2014).

This foundational perspective finds renewed depth in Descartes’ Error by António Damásio, who argues that the brain and body are integrated within a complex system that shapes our experience and interaction with the surrounding environment. He argues that emotion plays a crucial role in human cognition, challenging the dualist perspective of René Descartes, which separates mind and body. Drawing on case studies of patients with brain injuries, Damásio (1996) demonstrates that the ability to feel emotions is critical for decision-making.

But what is well-being? A concept as broad as it is subjective, it can encompass several dimensions, including physical, emotional, and social well-being. Over time, this concept has evolved, reflecting changes in social, cultural, economic, and scientific perspectives. Previously, well-being was often associated solely with the absence of illness or physical discomfort. However, this narrow view has expanded to encompass a broader understanding of human life. One of the most notable shifts has been from an individual-centred to a more holistic and integrated approach. The World Health Organization’s founding charter had already foreshadowed this holistic stance, defining health as “a state of complete physical, mental and social well-being” (Constitution of the World Health Organization, 1946).

Physical well-being involves diet, exercise and rest; emotional well-being relates to stress regulation and mood; and social well-being reflects the quality of interpersonal relationships. Crucially, each dimension is filtered through the “phenomenological lens” of individual experience, meaning that identical settings can support or hinder well-being depending on the user’s values and expectations. Today, well-being is seen as a state of equilibrium and harmony among different life aspects, including physical and mental health, interpersonal relationships, job satisfaction, life purpose, and connection with the community and environment.

In recent years, the design of spaces oriented towards well-being has gained prominence, particularly with the growing interest in both physical and mental health. This focus intensified following the onset of the COVID-19 pandemic in 2020, when prolonged home isolation underscored the need for spaces that offer both physical and emotional comfort.

Nevertheless, the connection between design, architecture, and well-being is not new. It has been explored throughout history by prominent figures whose contributions shaped the foundations of the Modern Movement. As Barata (2008) notes, William Morris (1834–1896), associated with the Arts and Crafts movement and regarded by many as a pioneer of modern design and architecture, as well as a thinker and political figure, emphasised the relationship between art, design, and social well-being. He advocated for quality design and artisanal production as essential means to improve people's lives. His approach, focused on craftsmanship and aesthetics, aimed to reintegrate beauty and function into everyday life, in reaction to the unchecked industrialisation of the 19th century.

Barata (2008) also highlights the role of Walter Gropius (1883–1969), founder of the Bauhaus in 1919 and one of the key figures in consolidating the Modern Movement. Gropius promoted the integration of art, architecture, and technology in the creation of more efficient and harmonious environments, placing the well-being of occupants at the centre of design. Under his leadership, the Bauhaus aimed to reform artistic and architectural practices while cultivating individuals capable of promoting positive social change through a more humanistic and functional approach to design.

Both Morris and Gropius believed in the power of architecture and design to directly influence social well-being. For Morris, the aesthetic quality of environments was essential to improving quality of life, while Gropius saw formal harmony as a reflection of social harmony. Their perspectives highlighted the importance of a human-centred and integrated approach to design and architecture (Barata, 2008).

Christopher Alexander’s pattern language later codified recurring spatial solutions that “feel right” because they implicitly resonate with human biological and cultural needs (Alexander, Ishikawa & Silverstein, 1977). These historical trajectories converge on a human-centred ethos now strengthened by neuroscientific validation.

The relationship between design and human emotions has also been explored more specifically in contemporary design theory. There is a field within design dedicated to understanding the emotional responses elicited by objects. Grounded in psychology, Emotional Design, extensively studied by Donald A. Norman, offers a framework for understanding how design can evoke emotions. Norman (2004) based his theory on how mental processes lead to emotional responses, shaped by individuals' prior experiences. He identified three main levels of processing: the visceral level, related to immediate and instinctive responses to visual and tactile elements; the behavioural level, focused on pleasure and usability during interaction; and the reflective level, which involves meaning and personal interpretation. Addressing all three levels, Norman argues, allows design to enhance user experience and create positive emotional bonds with objects.

On the other hand, Daudt (2018) reflects on the limitations of designing solely for emotional responses, since emotions are short-term functional processes. As she notes, "designing for emotions means understanding that the emotional effects intended by a project will be momentary" (Daudt, 2018, p. 10). Consequently, Daudt (2018) highlights theoretical proposals that aim to promote long-term impacts on people's subjective well-being. In contrast to objective well-being, which concerns measurable aspects such as safety and physical health, subjective well-being relates to personal satisfaction and a positive outlook on life.

In this context, Positive Design, inspired by the principles of Positive Psychology, emerges as an approach aimed at fostering subjective well-being. It focuses on three key elements: design for virtue, design for pleasure, and design for personal meaning. When these elements intersect, they help individuals explore their full potential and find purpose in their lives. While each component may function independently, Positive Design places emphasis on their integration to promote long-term well-being.

As the understanding of well-being has evolved, so too has the awareness that environments actively shape our mental and emotional states. This recognition has enabled valuable insights to emerge across multiple disciplines, ranging from qualitative studies to empirical knowledge rooted in scientific research. The growing need for a more interdisciplinary approach, integrating neuroscience, psychology, design, and related fields, has paved the way for more cohesive and evidence-based design strategies. This perspective continues to gain momentum as scientific knowledge increasingly informs how we conceive, inhabit, and emotionally engage with the environments around us.

Interdisciplinarity, when adopted as a structuring principle of the design process, stems from the recognition that the challenges faced by contemporary projects, from urban planning to micro-scale interior interventions, are inherently complex, multi-scalar, and laden with social, environmental, and cultural implications. In this context, the isolated contribution of a single discipline is likely to produce partial responses; only the dialogue between distinct fields can articulate the full range of variables that shape human experience within the built environment (Norman, 2023).

From an epistemological standpoint, multidisciplinary design is grounded in four foundational principles. (i) Systems thinking: the project is understood as an open system in which form, function, meaning, and environmental impact are mutually influential (Meadows, 2008). (ii) Translatable knowledge: neuroscientific concepts such as stress, for instance, become parameters for lighting decisions, while evidence from environmental psychology regarding attentional restoration informs the integration of natural elements (Kaplan & Kaplan, 1989). (iii) Co-creation and participation: lay knowledge and users' lived experience are regarded as essential data, ensuring that interdisciplinarity does not devolve into a technocratic exercise disconnected from real needs (Sanders & Stappers, 2008). (iv) Ongoing empirical evaluation: mixed methods, including physiological measurements, qualitative surveys, and post-occupancy performance analysis, enable the validation, refinement, and iterative feedback of the process, closing the loop between theory and practice (Zeisel, 2006).

The relevance of this approach becomes evident on multiple levels. Firstly, it enhances the quality of outcomes by integrating evidence related to health, cognition, sustainability, and equity. Secondly, it strengthens the designer's ethical responsibility by clarifying the necessary balances between comfort, cost, and social impact. Thirdly, it fosters innovation, as the intersection of heterogeneous perspectives creates "boundary spaces" from which unexpected ideas and methodological synergies may emerge. Finally, interdisciplinarity offers resilience: projects conceived by diverse teams tend to adapt more effectively to future technological, demographic, and climatic shifts.

Embracing design as an interdisciplinary act, entails relinquishing the figure of the "singular author" and assuming the role of mediator of knowledge. This repositioning does not weaken the designer's identity; on the contrary, it expands their scope, enabling the translation of scientific discoveries and societal aspirations into spaces that not only accommodate life, but actively enhance it in all its dimensions.

As design becomes increasingly informed by disciplines such as neuroscience and psychology, a new paradigm emerges, one that recognises space not merely as a container for activity, but as an active agent in shaping perception, emotion, and behaviour. By integrating functional, aesthetic, and emotional dimensions, design can become a powerful tool for fostering well-being in a meaningful and lasting way. This interdisciplinary vision paves the way for more empathetic and human-centred approaches to spatial creation, where environments are designed not just to accommodate life, but to enhance it.

CHAPTER 5. DESIGNING FOR THE BRAIN: THE RISE OF NEUROARCHITECTURE

Understanding how people respond to space at a neurological level has become increasingly relevant in contemporary design practice. This growing awareness has led to the emergence of design methodologies that take into account the brain's role in perception, emotion, memory, and behaviour. These approaches are grounded in the idea that spatial design can be more than intuitive or artistic, it can be informed by science. Insights into how the nervous system processes light, texture, geometry, and movement offer valuable tools for shaping environments that not only function well, but also promote health, clarity, and emotional connection. What was once considered a distant conversation between disciplines is now becoming a fertile ground for innovation, where architecture, design, and neuroscience converge to support more human-centred and meaningful spatial experiences.

This convergence was intuitively anticipated by Jonas Salk, the renowned physician and developer of the polio vaccine. As Matoso (2022) describes, during a visit to the 13th-century Basilica of Saint Francis of Assisi in Italy, Salk experienced a surge of creativity and inspiration that would later influence the development of his scientific work. Upon returning to the United States in 1962, he sought to recreate that experience by founding the Salk Institute for Biological Studies, a research centre focused on molecular biology, genetics, neuroscience, and plant biology. To bring this vision to life, Salk invited architect Louis Kahn to design a space that could unite art and science, blending functionality with beauty. The goal was to inspire scientists to pursue research with the same depth of passion and creativity that artists bring to their craft.

As stated by the Institute itself, the building was conceived to "create a collaborative environment where researchers could explore the basic principles of life and contemplate the broader implications of their discoveries for the future of humanity" (Salk Institute for Biological Studies, 2024). It became one of the earliest examples of a space designed specifically to enhance creativity and collaborative thinking. In Salk's own words:

> The Salk Institute is a curious place, not easily understood, and the reason for this is that it is a place in the process of becoming. It is being created and is engaged in the study of creation. We cannot be certain of what will emerge here, but we can be certain that it will contribute to the well-being and understanding of humankind. (Salk Institute for Biological Studies, 2024)

Figure 5

Institute Salk, Califórnia

Early empirical evidence of environment–health interactions came from Roger Ulrich, who found that postoperative patients recovered faster and required fewer analgesics when their ward windows faced trees rather than brick walls (Ulrich, 1984). Such studies catalysed a surge of interdisciplinary interest in what is now broadly termed *neuroarchitecture*, the application of neuroscience to architectural decision-making, and provided the scientific foundation for contemporary evidence-based design (EBD).

Architects and designers are often able to observe, in practice, the powerful influence that spaces exert on human behaviour. Within this context, many of them draw on tools developed in the field of Environmental Psychology, such as behavioural observation, interviews, and questionnaires. These methods are employed to identify patterns of behaviour and user motivation, aiming to gain a deeper understanding of how people perceive and interact with their surroundings.

Although environmental-perception studies and neuroarchitectural research share a common interest in human–environment interaction, they diverge in epistemic focus. The former is grounded in self-report and behavioural observation to establish how people *describe* and *display* experience (Gifford, 2014), while the latter interrogates the underlying neural mechanisms that *produce* those experiences, coupling spatial variables with patterns of brain activity (Sternberg, 2009). Viewing the two streams as complementary instead of hierarchical broadens the methodological palette available to interior designers pursuing evidence-based practice.

Neuroarchitecture is thus the field of study dedicated to deciphering the relationship between the built environment and the human brain, and to understanding how physical space can influence the well-being and cognition of its occupants. For Villarouco et al., (2021) neuroarchitecture is inherently multidisciplinary, combining neuroscience and architecture to develop projects informed by the interactions between neural activity and the constructed environment. These interactions are explored using methods and techniques drawn from both neuroscience and environmental design research, and can be broadly categorised into three groups:

• Environmental and behavioural research techniques, which include observational studies, self-reporting, archival data, and various forms of mapping. Common tools from environmental psychology—such as mental maps, behavioural maps, and cognitive maps—are frequently employed, as well as biosensor-based tracking technologies.

• Classical neuroscience techniques, which involve psychophysiological measurements through neuroimaging technologies such as EEG, ERP, MEG, PET, and fMRI. These techniques also include measures of electrodermal activity (skin temperature, galvanic response, and skin conductance), electromyography, heart rate, blood pressure and volume, and ocular movements (such as blinking).

• Digital tools and user-connected devices, which have become increasingly relevant, particularly in collaborative data collection (crowdsourcing). Devices such as cameras, microphones, and virtual or augmented reality (VR/AR) headsets are commonly used to gather spatial interaction data. One key application of these tools is eye-tracking technology.

In 2003, the Academy of Neuroscience for Architecture (ANFA) was founded in San Diego, California (USA), and the term “neuroarchitecture” began to be officially adopted. The work presented at ANFA’s inaugural conference by neuroscientist Fred Gage, principal researcher at the Salk Institute for Biological Studies, and architect John Paul Eberhard opened the door to discussions on how built environments affect human behaviour and well-being. These contributions had a significant impact on the architectural field (ANFA | History, n.d.).

Since then, neuroarchitecture has evolved both as an academic discipline and a field of practical inquiry. However, many of its foundational premises remain predominantly theoretical, with limited empirical validation through rigorous experimental studies. Although scholarly interest has grown steadily, and the body of literature has expanded, key neuroscientific constructs underpinning the field still require deeper investigation. This gap highlights the need for interdisciplinary collaboration to refine our understanding of how spatial design influences human cognition, emotion, and behaviour. As such, neuroarchitecture holds significant potential for future development and may profoundly reshape the ways in which architectural practice and design thinking are approached in the coming years.

Villarouco et al. (2021) also point out that although neuroscience experiments are capable of explaining specific neural interactions and brain activities, observing these phenomena within the body is not the same as experiencing the subjective meaning of space, its light, proportions, materials, and atmosphere. Bridging the gap between objective scientific data and subjective experience remains one of the central challenges of applying neuroscience to architecture.

Neuroarchitecture is based on an understanding of the brain’s structures and functions involved in spatial perception and environmental response. This includes the integration of sensory information, vision, hearing, smell, and touch, which is processed in different areas of the brain such as the visual, auditory, and somatosensory cortices. Emotional and cognitive responses are also triggered by environmental stimuli, involving key brain regions such as the limbic system, prefrontal cortex, and hippocampus, all of which play a role in motivation, memory, attention, and decision-making (Villarouco et al., 2021).

In *Architecture and Empathy*, Pallasmaa et al. (2015) reflect on how, when we design physical spaces, we are in fact creating experiences, shaping emotions, perceptions, and mental states. Scientific findings have already demonstrated that environments influence the nervous system to such an extent that they can modify the brain itself, and these changes in turn affect behaviour.

When studying brain plasticity, neuroscientist Fred H. Gage discovered early evidence that the adult human brain continues to generate new cells, a phenomenon known as neurogenesis. Gage showed that certain environmental stimuli could promote the growth of new brain cells in mammals. His revolutionary findings, published in the late 1990s, challenged the prevailing belief that the brain, unlike other organs such as skin or bone, lacked regenerative capacity. These discoveries not only expanded scientific understanding of the brain, but also laid the groundwork for future studies on stem cell therapy, gene therapy, and environmental and behavioural stimulation as potential treatments for central nervous system disorders (Rogers, 2023).

The impact of environmental design on the brain was further demonstrated in a study by Clemenson et al. (2015), which examined the relationship between environmental enrichment (EE) and neurogenesis. In this experiment, rodents were placed in enriched environments containing a variety of stimuli, such as toys, tunnels, bedding, and exercise wheels, to promote physical, social, and sensory engagement. The environment was regularly updated with new objects to maintain novelty. The study showed that EE had a positive effect on hippocampal neurogenesis and behaviour, leading to increased production of new neurons and improved hippocampus-dependent cognition. Mice exposed to this enriched setting for 40 days demonstrated a significantly higher number of granule cells in the hippocampus, as well as marked improvements in learning tasks, compared to those in standard housing conditions.

Since confirming the existence of adult neurogenesis, Gage has continued to investigate the role of these young neurons. His findings highlight how the architecture of the environment can influence not only neurogenesis but also cognitive well-being. In his publication *Neurogenesis in the Adult Brain*, Gage reflects on how the environment in which an organism lives, and in particular how it behaves within that environment, can affect both the rate and fate of newly generated brain cells. He raises a compelling question: with the right behavioural and environmental stimuli, might neurogenesis be induced in areas of the brain previously thought to be non-neurogenic? In other words, can human behaviour and the spaces we inhabit shape the brain to the point of generating new neurons? (Gage, 2002).

In this context, research in neuroarchitecture has contributed significantly to the practical application of neuroscience within the design process. It is important to clarify that references to neuroarchitecture, or architecture more broadly, are made with the understanding that these fields are inherently connected to interior design. Both disciplines share common goals and should be approached through a multidisciplinary lens to foster greater innovation and effectiveness in creating spaces.

This collaborative perspective is essential for designing environments that are not only functional and aesthetically pleasing, but also aligned with users' psychological and physiological needs. Ultimately, the aim is to shape healthier spaces that actively support human well-being. Moreover, neuroarchitecture offers a valuable foundation, as many of its studies and findings provide insights highly relevant to the practice of interior design, offering evidence-based guidance to inform more conscious and human-centred design decisions.

CHAPTER 6. BASIC FOUNDATIONS OF NEUROSCIENCE: UNDERSTANDING THE HUMAN BRAIN

As established previously, our experience of space is not limited to recognising its form or function. It is shaped by how we feel within it, how we remember it, and how our senses respond to it. These layers of perception, emotional, sensory, and cognitive, are all processed through the nervous system, highlighting the profound link between the human body and the built environment. Understanding this connection calls for more than aesthetic or functional considerations. It requires a shift in perspective, one that embraces the complexity of human experience and recognises that design is deeply intertwined with how the brain interprets and reacts to space. To design with human well-being in mind, it becomes essential to explore the interdisciplinary field of neuroscience, even at a foundational level.

Modern neuroscience is profoundly illuminating how interior environments shape human experience. People today spend nearly 90% of their time inside buildings, and thus the design of these spaces has significant impacts on our brains and behaviour. In essence, buildings do more than shelter our bodies, they also engage our memories, emotions, and even unconscious mental states (Santos, 2023). Architecture can therefore become a "key element capable of unconsciously modifying our emotions, thoughts, decision-making processes, physiological state, and health" (Santos, 2023, p.177).

Spatial experience is not confined to the recognition of form and function; it is deeply embedded in the sensory, emotional, and cognitive processes regulated by the human nervous system. From perceiving textures and light to evaluating safety and comfort, these dimensions of experience emerge through complex neural mechanisms that link external stimuli with internal states. This understanding requires interior designers to move beyond formal aesthetics and adopt a neurobiological perspective, acknowledging that to design is to shape experience at a physiological level (Eberhard, 2009).

Bear et al. (2017) emphasise this interdisciplinary nature, explaining that historically, those who dedicated themselves to studying the nervous system have come from a range of scientific backgrounds, medicine, biology, psychology, physics, chemistry, and mathematics. The true revolution in neuroscience, they argue, occurred when these disciplines converged, allowing a synthesis of methods and perspectives to emerge:

> The revolution in neuroscience came when these scientists realised that the best approach to understanding how the brain works was through an interdisciplinary lens, a combination of traditional methods aimed at producing a new synthesis, a new perspective. (Bear et al., 2017, p. 46)

At its core, neuroscience is the scientific study of the nervous system, with particular emphasis on the brain, an organ central to perception, cognition, and behaviour. Recent advances have highlighted its relevance not only within other scientific disciplines but also in emerging areas of application, including the design of built environments (Gonçalves & Paiva, 2018).

De Paiva (2018) draws attention to a particularly striking finding: only a small fraction of the brain's processing power, less than 1%, operates at the conscious level. Most environmental stimuli are processed subconsciously, influencing behaviour, perception, and mood without the individual's awareness. This has profound implications for design, as spaces can affect people's mental and physical states even when those effects are not consciously recognised.

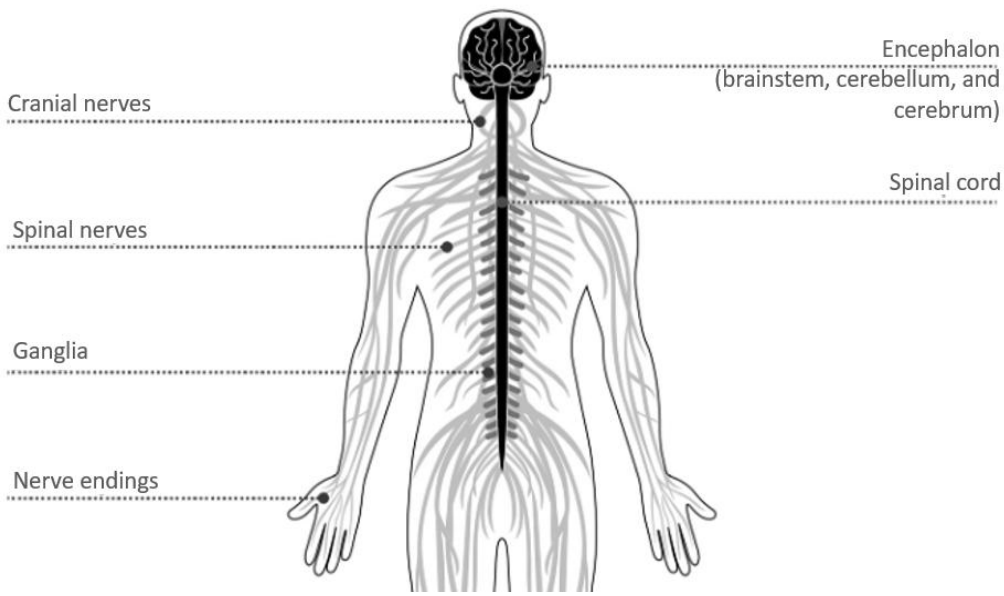
It is therefore vital to understand the basic fundaments of anatomy and physiology of the nervous system in order to correlate its functional properties with the reactions triggered by environmental stimuli. Today, it is well established that different areas of the brain are activated by electrical patterns generated through perception and sensation. Understanding which stimuli activate which regions, and how frequently, allows for a more informed and intentional use of spatial design. As Villarouco et al. (2021) notes, "neuroscience not only explains how a reaction occurs, but also why it occurs."

One of the key areas of investigation in neuroscience-informed design is the nervous system itself, which coordinates, integrates, analyses, and stores information received from external and internal stimuli. Structurally, it is divided into the central nervous system (CNS) and the peripheral nervous system (PNS), each of which plays distinct morphological and functional roles in the human body (Villarouco et al., 2021).

As demonstrated in Figure 6, the central nervous system (CNS), comprising the brain and spinal cord, is enclosed within the protective structures of the skull and vertebral column. In mammals, the brain or encephalon, is anatomically divided into three principal regions: the cerebrum, the cerebellum, and the brainstem. The cerebrum, the most rostral and largest component, is split into two hemispheres by the sagittal fissure. Each cerebral hemisphere is functionally specialised to process sensory information and coordinate motor responses for the contralateral side of the body. Posterior to the cerebrum lies the cerebellum, which, despite its smaller size, contains as many neurons as both cerebral hemispheres combined. It functions primarily as a centre for motor coordination and maintains extensive connections with both the cerebrum and the spinal cord. In contrast to the cerebrum, each side of the cerebellum controls movement on the ipsilateral side of the body. The brainstem, located beneath the cerebrum and anterior to the cerebellum, serves as a critical relay centre, transmitting information between the cerebrum, cerebellum, and spinal cord. Beyond its integrative role, the brainstem is responsible for regulating vital autonomic functions, including respiration, consciousness, and thermoregulation. The spinal cord, directly continuous with the brainstem, acts as the main conduit for neural signals between the brain and the peripheral body. It receives and transmits information related to sensory inputs and motor outputs via spinal nerves (Bear, 2020).

Figure 6

Division of the Nervous System Based on Anatomical Criteria of the Human Body



The peripheral nervous system (PNS), comprising all neural structures outside the brain and spinal cord, is divided into the somatic and visceral components. The somatic PNS controls voluntary movements and transmits sensory information from the skin, muscles, and joints. The visceral PNS, or autonomic nervous system (ANS), regulates involuntary functions by controlling internal organs, blood vessels, and glands. It relays sensory information such as blood pressure and coordinates responses like heart rate and digestion (Bear, 2020).

The cerebral cortex is a thin, densely folded layer of grey matter that acts as the brain's control panel. It is organised into five classic lobes, each retaining its technical name while performing everyday functions we recognise: the frontal lobe plans our actions and moves our muscles; the temporal lobe helps us hear and store memories; the parietal lobe gathers touch and body-position information so we know where we are in space; the occipital lobe turns light into vision; and the insula links body feelings (like a racing heart or “butterflies”) with emotions. At the very front, the prefrontal cortex, a subset of the frontal lobe that expanded markedly in human evolution, supports abstract reasoning, impulse control and long-range decision-making (Idem, 2020).

Neuroscience has shown that the cortex constantly receives sensory feedback, highlighting the brain-body connection. This loop is fundamental for regulating perception, motor control, arousal, homeostasis, motivation, learning, and memory (Villarouco et al., 2021).

Neuronal communication relies on three functional classes: afferent neurones transmit sensory data to cortical centres; efferent neurones convey motor directives to effector organs; and interneurones mediate intracentral processing, forming dynamic sensorimotor loops. The somatosensory system, encompassing touch, proprioception, thermoception and nociception, provides continuous feedback about body position and environmental threat. Such feedback is essential for maintaining arousal, postural control and perceptual accuracy, capacities directly influenced by spatial layout, material tactility and ambient conditions (Bear, 2020).

Neurons act as the nervous system's primary messengers, converting information into electrical impulses that travel along the axon and into chemical signals released at synapses. Each neuron contains a soma (cell body) housing the nucleus, branching dendrites that receive incoming signals, and a single axon that carries outgoing messages. These neuron-to-neuron links support every mental activity, from perception and memory to decision-making. Surrounding them are glial cells, which supply metabolic fuel, maintain structural scaffolding, and fine-tune synaptic transmission. Chemical messengers known as neurotransmitters, including serotonin, dopamine, oxytocin, and noradrenaline, further modulate mood, motivation, and social behaviour, illustrating the intricate chemistry behind thought and emotion (Bear, 2020). As Hippocrates observed in the 4th century BC:

> Men ought to know that from the brain, and from the brain only, arise our pleasures, joys, laughter and jests, as well as our sorrows, pains, griefs and tears... and by the same organ we become mad and delirious, and fears and terrors assail us. (as cited in Bear et al., 2017, p. 46)

This ancient insight remains deeply relevant, affirming the brain's central role in shaping human experience and reinforcing its importance in disciplines such as neuroarchitecture, where spatial design seeks alignment with cognitive, emotional, and behavioural processes. Understanding the structure and function of the nervous system is a complex and evolving process, yet it is essential for the field of neuroarchitecture, as spatial design should be grounded in multidisciplinary findings from neuroscience and an understanding of the neural bases of human behavior.

The convergence of neuroscience and interior design has led to a more evidence-based, user-centred design paradigm. Designers are no longer limited to intuition or aesthetics alone; they can now base their decisions on scientific research and empirical data, an approach formalised as *evidence-based design (EBD).* In EBD, design proposals are informed by the best available evidence about how the environment will affect end users' health, mood and performance. The influence of Ulrich's 1984 study can be seen here: by quantifying outcomes, it encouraged architects to systematically test and incorporate features that benefit occupant (Mitchell, 2010).

Today, evidence-based design extends beyond hospitals to workplaces, schools, and homes, integrating findings from environmental psychology and neuroscience into the design process. For example, if cognitive science shows that certain classroom layouts improve students' attention, an evidence-based school design will factor that in. If brain research finds that cooler colour palettes and diffuse lighting reduce stress, an office design might adopt those elements in high-pressure areas.

This represents a cultural shift toward interdisciplinary collaboration mentioned previously, where architects, interior designers, psychologists, and neuroscientists work together to create spaces that are both beautiful *and* empirically validated to support human well-being. One concrete model of such collaboration is evident in the work of the Academy of Neuroscience for Architecture (ANFA), which acts as a global hub connecting neuroscientists and design professionals and facilitates joint research initiatives, educational programmes, and knowledge translation to bridge the gap between laboratory findings and practical architectural application. Through these exchanges, spatial design becomes grounded in measurable neurological responses such as stress reduction, attention regulation, and emotional comfort (ANFA | History, n.d.). ANFA brings researchers and designers together to study how the brain perceives built space and to translate scientific insights into architectural innovation. As Sternberg describes, such collaborations *"bridge the knowledge gap"* between neuroscience and architecture, ensuring that design professionals stay informed about how factors like spatial geometry, lighting spectra or material properties might affect occupants at a neural level (Mitchell, 2010).

A core principle in this integrative approach is user-centred design, meaning the needs and experiences of the end user drive the design decisions. Neuroscience enriches this by providing objective insights into those needs – including the often hidden cognitive or sensory requirements of different user groups. For instance, designing for older adults with cognitive decline benefits greatly from neuroscience knowledge about aging brains. John Zeisel's work on dementia-friendly design, mentioned earlier, is a prime example: by understanding how Alzheimer's disease affects memory and spatial orientation, designers can implement supportive features (clear signage, spatial layouts that encourage routine, memory nodes like display cases of personal mementos) that help dementia patients function with less confusion and anxiety (Zeisel, 2013).

Similarly, for neurodivergent individuals (such as those on the autism spectrum who might be hypersensitive to noise or patterns), neuroscience can inform adjustments like providing quiet zones, controlled lighting, or simple, predictable decor to prevent sensory overload. A one-size-fits-all approach is no longer acceptable, the interdisciplinary research teaches us that different brains may require different environments to thrive. This approach encourages empathy-driven, inclusive design backed by science: whether it's *trauma-informed design* for people recovering from stress (using calming, safe-feeling spaces to avoid triggering the brain's fear circuits), or *biophilic design* in workplaces (using natural elements to activate innate relaxation responses and improve creativity), the overarching goal is the same. It is to create environments that truly *serve their users' neurological and psychological well-being*. By iteratively researching, designing, and testing how spaces influence people, interior designers become akin to applied neuroscientists, crafting interventions in lighting, layout, and materials that can reduce stress, sharpen focus, or build social connection as needed. The payoff is evident in outcomes, higher productivity and satisfaction in offices, faster healing in hospitals, better learning in schools, and greater overall happiness in homes (Santos, 2023).

By applying research from figures like Damasio on emotion, Ulrich on healing environments, Ellard on spatial experience, Sternberg on stress and place, and many others, we can ground design decisions in scientific evidence and human biology. This scientific input does not detract from creativity; it enhances it by guiding creative choices to be more effective and humane. The future of interior design, therefore, lies in this interdisciplinary synergy: leveraging neuroscience to create spaces that not only look appealing but also feel and function appropriately for those who inhabit them. It is a future where design decisions are grounded in research, and the built environment becomes a catalyst for human potential and well-being.

CHAPTER 7. NEUROSCIENCE-INFORMED DESIGN: TRANSFORMING INTERIORS THROUGH NEUROSCIENCE

As our understanding of how the human brain responds to spatial stimuli continues to deepen, and how these responses shape behaviour, it becomes increasingly essential to evaluate the components of space through the lens of neuroscience. In view of the concepts and insights discussed thus far, the design process and the selection of spatial elements must be reconsidered and refined in light of evidence-based, neuroscience-informed approaches.

Over the past decade, numerous studies within the field of neuroarchitecture have demonstrated that spatial attributes, such as colour, form, lighting, texture, and material, have a profound impact on cognitive performance, emotional states, and physiological responses. This growing body of evidence has catalysed a paradigm shift in design thinking. The so-called "neuroscientific revolution," as referenced by scholars such as Sarah Robinson and Juhani Pallasmaa, has increasingly influenced architectural practice, prompting both architects and researchers to ground design decisions in scientific knowledge.

However, this approach does not aim to replace intuition or empirical experience. It promotes the inclusion of evidence-based design as an additional resource, one that works alongside traditional ways of thinking to strengthen the designer's capacity to respond to the complex and multifaceted nature of human needs.

7.1 COLOUR

Colour remains one of the most extensively examined environmental attributes in the domains of environmental psychology and, more recently, neuroarchitecture. Traditionally, the chromatic palette of a space has been associated with psychological effects, evoking sensations such as calm, stimulation, or comfort. From a neuroscientific standpoint, colours perceptually engage neural circuits linked to mood regulation and cognition, modulating levels of arousal, emotional states, and even physiological markers such as heart rate and hormonal responses.

Variations in hue and chromatic saturation are capable of eliciting distinct reactions within the autonomic nervous system and across cortical regions. For instance, neurophysiological research suggests that environments dominated by blue tones are associated with increased parasympathetic activity, fostering a state of relaxation and enhancing autonomic variability, while also modulating emotional processing in the brain. Thus, cooler tones may be applied in spaces intended for rest and relaxation, such as living rooms in residential settings, as illustrated in Figure 7. In contrast, warm and saturated colours, particularly red and orange, used in more stimulating environments like playgrounds (also shown in Figure 7), have been shown to increase physiological and cognitive arousal, potentially reducing the perceived sense of environmental control. These colours are therefore more appropriate for activity-oriented spaces (Küller et al., 2009). As a general trend, interiors characterised by soft or neutral tones are experienced as calming, whereas highly saturated schemes tend to produce environments that are more stimulating, and in some cases, potentially stress-inducing.

Figure 7

Orange vs Blue: Contrasting Emotional Effects of colour in Interior Design

Crucially, the influence of colour extends beyond affective responses. It also affects cognitive functioning and subjective preferences. Empirical studies in environmental psychology have demonstrated that different colours may support specific cognitive tasks. For example, red hues have been linked to enhanced performance in tasks requiring attention to detail, while blue tones appear to foster creativity and abstract reasoning (Mehta & Zhu, 2009). However, these associations are not universal.

Afifi et al. (2023) contend that the experience of colour in architectural contexts must be understood as a multidimensional phenomenon, one that encompasses symbolic associations, autobiographical memory, and immediate neurophysiological reactivity. In a study employing virtual reality and EEG recordings, Bower et al. (2023) demonstrated that altering the colour scheme of an interior setting resulted in measurable changes in both brain connectivity patterns and autonomic emotional indices. These findings affirm that colour schemes function as sensory stimuli capable of shaping emotional experience in architectural space.

Notably, the perceptual and behavioural impact of colour is significantly modulated by lighting conditions. Colour and light do not function as isolated visual elements; instead, they interact to influence spatial perception, cognitive performance, and emotional states, factors essential to interior design. Recent experimental findings demonstrate that the chromatic composition of a space, especially in relation to its lighting temperature, can alter occupants' behaviour and mental states in measurable ways. Afifi, Krumrei-Mancuso, and Trammell (2023), for instance, found that environments with cool-toned colours (blue walls) under cool lighting enhanced both creative output and response time in cognitive tasks. Conversely, warm-toned settings (red walls with warm light) were linked to increased agitation and decreased task accuracy. Interestingly, contrast between wall colour and light temperature, such as blue walls with warm light, was associated with reduced negative affect, indicating that perceptual tension may have a regulatory effect on mood.

For design practice, these results highlight the need to strategically calibrate colour and lighting to align with the intended use and behavioural goals of a space. In creative environments, such as studios, classrooms, or brainstorming zones, cool hues complemented by moderate lighting may boost ideation and sustained attention. In contrast, restorative spaces (waiting rooms, lounges, or recovery areas) may benefit from warmer palettes softened by cooler or neutral lighting, promoting psychological comfort without inducing lethargy. Importantly, designers must avoid overstimulation in such environments, as highly saturated colours like bright red or orange can trigger hyperarousal and undermine relaxation. By understanding these neuropsychological dynamics, interior designers can shape atmospheres that support desired behaviours and emotional states, ensuring that chromatic and luminous elements serve not just aesthetic goals but also human-centred functionality.

Despite promising findings, it is essential to acknowledge the methodological limitations present in much of the literature. A substantial portion of the research is conducted in laboratory or virtual environments, in which variables such as colour and lighting are experimentally isolated. In real-world settings, sensory experience is shaped by a convergence of stimuli, visual, auditory, tactile, and spatial. Furthermore, colour perception is deeply subjective, shaped by cultural background, personal experience, and neurobiological diversity. Thus, colour strategies in design practice must remain flexible and context-aware.

In addition to physiological and cognitive considerations, colour holds powerful symbolic and emotional significance. As Rangel and de Souza Matos (2021) argue, colour functions as a form of non-verbal communication, influencing perception through associations often embedded in cultural memory and personal experience. De Paiva (2018) further notes that colour processing is not confined to the visual cortex but also involves neural regions associated with emotion and memory. Colour has been shown to enhance memory recall, and familiar objects are often perceived in their prototypical colours, even when presented in greyscale, evidence of the brain's integration of colour and cognition.

Within these concepts, colour becomes a fundamental design tool capable of evoking emotion, triggering memory, and simulating natural environments. Blue walls may evoke the open sky, green flooring may suggest grass or natural ground, and earth tones may reference tactile materials such as stone or clay. These chromatic cues contribute to the spatial narrative and promote psychological well-being.

Contemporary research in neuroarchitecture reinforces long-standing insights from colour psychology while offering empirically grounded, multidimensional perspectives on chromatic experience. Designers are increasingly equipped with evidence-based strategies that move beyond aesthetic trends or stylistic decisions, towards human-centred interventions.

7.2 FORM AND PROPORTION

The shape and geometry of architectural spaces and objects exert a profound influence on how individuals perceive and emotionally engage with their surroundings. Recent advances in neuroscience have begun to illuminate the mechanisms underlying these effects. Functional neuroimaging studies demonstrate that the human brain exhibits differential responses to curved and angular forms. For instance, Vartanian et al. (2013) found that curved architectural shapes are generally perceived as more aesthetically pleasing, whereas angular geometries tend to elicit heightened activation in the amygdala, a brain region associated with threat detection, thereby correlating with increased negative affect and sensations of discomfort. As observed in Figure 8, environments characterised by sharp edges and acute angles may subtly evoke a state of alertness or tension, while spaces incorporating organic contours and fluid curves often promote sensations of safety and psychological ease.

Figure 8

Curves vs Angles: How Spatial Geometry Shapes Emotional Perception

Beyond curvature, spatial configuration, such as open plan versus compartmentalised layouts, also plays a crucial role in modulating affective and cognitive states. Using functional magnetic resonance imaging (fMRI), Vartanian et al. (2015) observed increased activation in prefrontal regions associated with reward processing when participants evaluated open-plan interiors, in contrast to more enclosed spatial arrangements. Open environments are frequently perceived as affording greater freedom and exploratory engagement, whereas closed or overly segmented layouts can elicit sensations of restriction or claustrophobia, particularly when users perceive a lack of control over the spatial conditions.

Complementing these findings, a pioneering study by Djebbara et al. (2019), employing mobile electroencephalography (EEG), revealed that architectural forms convey "affordances", that is, implicit invitations to action, which the brain processes at a pre-conscious level as individuals move through space. For example, the presence of a gently curving pathway or a low ceiling triggers distinct anticipatory neural responses when compared to straight corridors or expansive, high-ceilinged halls. These sensory-motor dynamics suggest that form actively shapes spatial navigation, influencing both movement and psychological readiness.

Such findings underscore that architectural form transcends aesthetics. It functions as a regulatory agent for behaviour and mental state. While curves may encourage approach and restfulness, sharp angles and complex geometries can heighten attention or, if overapplied, risk inducing cognitive overload.

With the advent of neuroscience, scholars have turned their attention to how such proportions impact emotional and behavioural responses. Zeisel (2006) argues that scale significantly influences perceived safety and social interaction. Overly expansive spaces may feel overwhelming, whereas overly confined spaces risk inducing anxiety or discomfort. Additional insights come from research on ceiling height. Meyers-Levy and Zhu (2007) found that higher ceilings foster abstract thinking and expansive cognition, while lower ceilings are more conducive to focus and task-oriented mental states. Vartanian et al. (2015) further demonstrated that ceiling height influences not only perceived beauty but also neural efficiency in information processing, with higher ceilings being evaluated as more pleasant overall.

Given these insights, designers working within pre-existing architectural constraints can adopt non-structural strategies to modify users' spatial perception. Techniques such as differentiated ceiling and wall colours, dynamic lighting design, and deliberate interior layout arrangements can profoundly reshape how a space is experienced. For instance, darker ceiling tones can visually lower the height of a room, fostering a sense of intimacy, while lighter tones expand vertical perception, promoting openness. Similarly, the use of horizontal or vertical graphic elements, lighting gradients, and spatial zoning through furniture placement can subtly influence whether a room feels expansive or enclosed. These sensory manipulations enable designers to meet emotional and cognitive goals, even when architectural modifications are not feasible.

7.3 TEXTURES AND MATERIALS

Touch is the first sense to develop, even before birth. Although often overlooked in design guidelines, the tactile sense plays a vital role in fostering connection between people and the spaces they inhabit. The skin, our largest sensory organ, informs us of temperature, pressure, and texture (De Paiva, 2018).

The somatosensory system processes tactile information and spatial awareness, encompassing touch, texture recognition, temperature, pain, and proprioception (Villarouco et al., 2021). Textures elicit both sensory and emotional responses. Natural, rough surfaces like stone convey solidity and connection to nature, while smooth, cold materials such as metal may feel impersonal despite being aesthetically modern.

Juhani Pallasmaa (2012), in *The Eyes of the Skin*, critiques the dominance of visual aesthetics in architecture, advocating for a more multisensory approach. He laments the loss of existential sincerity in favour of image-driven design. Integrating touch into architectural design represents a critical frontier for neuroarchitecture. Moving beyond mere visual aesthetics, tactile experience offers a rich domain for fostering meaningful and human-centred spaces.

Beyond form and colour, the materials and textures that cover floors, walls, furniture, and objects define the sensory atmosphere of a space. As shown in Figure 9, materials can feel "warm" or "cold" to the touch and sight, and textures may be smooth and reflective or rough and absorbent. These tactile-visual qualities influence our responses both consciously and unconsciously.

A recurring theme in research is the hypothesis that natural materials promote greater relaxation and well-being than synthetic materials or sterile finishes. This idea, related to biophilia (addressed in the next chapter), now has measurable empirical support. For example, a systematic review on neuroarchitecture highlighted findings where the use of wood in interiors led to physiological stress responses, such as reduced heart rate and skin conductance (sweating), even when users did not consciously report significant differences (Assem et al., 2023).

In a classic controlled study, Zhang et al. (2017) compared identical rooms constructed with natural wood interior cladding versus smooth artificial material, monitoring various physiological parameters of volunteers performing office activities in these environments. The results showed less muscle tension and accumulated fatigue in the wooden room, as well as more balanced autonomic nervous system indicators (such as heart rate variability suggestive of greater parasympathetic response, a state of relaxation). Notably, these benefits occurred without participants necessarily perceiving the reason, objective measures indicated improved physiological condition in the wooden rooms, although subjectively many did not report significant differences in comfort. This indicates that natural materials act subtly and subconsciously: the visual texture of wood, its irregular organic patterns, and possibly even its imperceptible scent can engage the brain similarly to the natural environment, triggering a "rest response" that reduces basal stress.

Figure 9

Material Complexity vs Uniformity: How Surface Choices Shape Atmosphere

Corroborating this line, studies compiled by (Shanahan et al., 2019) have shown that interiors with natural elements, including materials like wood and stone, tend to lower sympathetic nervous system activity (linked to the fight-or-flight response) compared to entirely artificial interiors of plastic, glass, or exposed concrete. Practically, this means, for example, that an office with wooden ceilings and furniture can provide employees with healthier physiological rhythms (lower average blood pressure during the day, better heart rate variability) than an ultra-modern office entirely in metal and glass, even if both have similar ergonomics and lighting.

Thus, from a neuroscientific perspective, natural materials act almost like "micro-restorative pauses" within the indoor daily life: our senses microprocess the textures and organic tones, translating into cognitive load relief and relaxation response, aligned with Attention Restoration Theory (Kaplan, 1995) and other environmental psychology theories.

On the other hand, recent investigations also bring important nuances: merely the presence of a "visual" natural material is not always sufficient to significantly alter the cognitive or affective experience. A study published in 2025 examined via fMRI how the brain distinguishes "naturalised" interior environments (with a high presence of elements like wood, plants, stones) versus artificial environments, while participants evaluated such scenes. Contrary to expectations, the results indicated that the "naturalness" factor had minimal impact on subjective evaluations of beauty or space preference. People did not systematically rate naturalistic interiors as better than artificial ones, and, neurobiologically, the differences in brain activation between viewing a "green" room scene versus a "high-tech" style room were mainly restricted to lower visual areas. In other words, the brain perceived differences in textures and colours (different visual patterns), but did not strongly engage emotional or associative memory circuits beyond the visual cortex (Sztuka et al., 2025). These findings suggest that simply placing natural materials in the scene, without context or meaningful connection with the user, may not, by itself, generate significant conscious preference changes or intense emotional responses.

In design terms, this warns that superficial or scenic biophilia, like applying a wood-like laminate on all walls without criteria, may not bring the desired benefits if the environment as a whole is not coherent or if the user does not have the opportunity to interact with and appreciate these materials. Thus, the quality of the material experience matters: a real wood surface that the user touches, smells, or sees change in tone with light will have a greater impact than a static pattern merely visually present.

Regarding textures and visual complexity, neuroscience also offers insights. Completely smooth, shiny, and monochromatic environments (like some extreme minimalist designs) can, in the long term, induce a certain monotonous sensory overload, paradoxically, the lack of variation requires the brain to exert more effort in seeking stimulus. According to Hagerhall et al. (2008), EEG studies have shown that prolonged exposure to repetitive patterns and homogeneous surfaces can reduce alpha wave activity related to relaxation, suggesting that the occupant remains in a slight state of restlessness or boredom. In contrast, natural textures present fractal patterns and stochastic (almost random) variations that the brain processes fluidly, activating a kind of "soft attention" that is restorative. Richard Taylor and colleagues, demonstrated that fractal patterns of medium complexity, common in wood textures, leaves, stones, generate greater alpha wave production in the brain, correlating with subjective stress reduction in up to 60% of tested cases (Taylor et al., 2005). This line highlights a crucial point: texture is not noise, but visual information that can soothe. Contemporary interior design projects already incorporate this idea by reintroducing textured walls, natural fabrics, and less polished finishes, to break sensory monotony and engage the user. Neuroscience supports this practice by showing that the human mind thrives with a moderate degree of sensory complexity, tactile and visual textures provide this, stimulating somatosensory and visual receptors in a pleasant and non-threatening way.

Thus, the implications for architectural design are clear: selecting materials is not just an aesthetic or technical performance issue, but also a sensory design decision with psychophysiological impacts. Spaces that aim to promote tranquillity, connection, and health should prioritise natural or biophilic materials—wood, bamboo, stone, exposed brick, organic fabrics—in finishes and furniture in contact with people. Beyond visual appeal, direct tactile experience should be encouraged: for example, a wooden handrail instead of cold metal, or furniture with linen upholstery instead of plastic, can imperceptibly improve users' mood throughout the day. In cases where synthetic materials are unavoidable (hospital hygiene requirements demanding washable surfaces), designers can compensate by introducing nature-inspired visual textures, warm lighting that highlights surface variations, or natural decorative elements (living Figures, running water) to add sensory layers. Also important is the balance between diversity and cohesion: a chaotic environment mixing materials can overwhelm, so the strategy should be to integrate some key textures repeated at focal points, so that the brain recognises an order.

Thereby, neuroscientific research reaffirms the intuitive wisdom that materials matter as much as forms in creating uplifting atmospheres. Natural and textured materials help reduce stress responses and improve comfort in a subtle yet cumulative way. Excessively artificial or sterile surfaces can deprive the senses of positive stimulus, possibly contributing to fatigue or undefined malaise over time. As we incorporate this knowledge, we design spaces that feel as good as they function, where the texture of the wall, the touch of the floor, and the visual warmth of wood silently collaborate for the occupants' mental balance.

7.4 LIGHTING

Lighting is one of the environmental factors most directly linked to biological rhythms and emotional states, making it a central pillar of neuroarchitectural practice. Ambient light, both natural and artificial, affects the secretion of key hormones such as melatonin and cortisol, thereby influencing circadian sleep, wake cycles and, in turn, impacting physical health, emotional balance, and cognitive functioning.

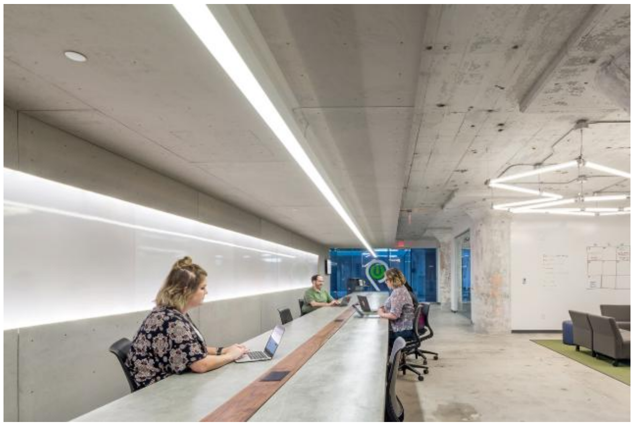
An abundance of natural daylight within built environments is consistently associated with positive outcomes: enhanced mood and environmental satisfaction, increased productivity, and improved circadian alignment. These benefits translate into better sleep quality and a reduction in symptoms of depression. Morning exposure to sunlight, in particular, plays a critical role in synchronising the biological clock, elevating daytime alertness and facilitating restorative rest at night. For these reasons, design strategies that maximise the intake of daylight are widely recognised as beneficial to human health.

Indeed, empirical studies have shown that office workers with access to windows and external views report higher levels of well-being and lower rates of eye strain and headaches compared to those in windowless environments (Figueiro et al., 2017). In the realm of artificial lighting, technological advances have enabled the development of neuro-informed approaches such as “integrative lighting” or “human-centric lighting.” These approaches consider not only the visual attributes of light but also its biological effects. The colour temperature and intensity of light can be modulated throughout the day to simulate natural patterns: cool, bright lighting in the morning and afternoon enhances alertness and performance, while warm, dimmed lighting in the evening promotes relaxation and reduces melatonin suppression.

Assem et al. (2023) underscore that warm-toned, moderate-intensity lighting is particularly conducive to reflection and critical thinking in discussion settings, whereas cool, high-intensity lighting is more suitable for tasks demanding sustained cognitive effort. These findings suggest that different lighting qualities elicit distinct mental states: cool light stimulates and energises, while warm light soothes and comforts. This contrast is clearly exemplified in Figure 10, where warm lighting is applied in the living room to create a calming, restful atmosphere, while cooler, brighter lighting is used in the adjacent workspace to support focus and mental clarity.

Figure 10

Warm vs Cool Lighting: Selecting Light Temperature to Support Function and Mood



Another crucial element is personal control over lighting conditions. Allowing users to adjust the intensity or colour temperature of their environment, via adjustable luminaires or shading systems, has been shown to foster a sense of empowerment that translates into increased well-being and satisfaction. Personalised control over lighting is among the most effective strategies for enhancing workplace performance and psychological comfort (Assem et al. 2023).

Efficient use of light, particularly natural light, has a direct impact on health and spatial orientation. Warm lighting tones promote calmness, while cooler tones may enhance alertness or, conversely, provoke stress (Küller, 2006). Smolders and Kort (2014) found that brighter light improved alertness and vitality, especially after mental fatigue, critical for learning and work environments. Similarly, Heschong et al. (2002) showed that students in classrooms with natural light performed better academically. These findings confirm that lighting is integral not only to visibility but to overall human functioning and well-being.

Furthermore, the qualitative and aesthetic aspects of lighting must not be overlooked. Soft shadows, uniform luminance, and the absence of flicker contribute to a visually pleasant experience that helps prevent fatigue. Lighting also influences the perception of space and form: directional light that highlights textures or introduces contrast can make an environment more engaging and legible, while flat, diffuse lighting may result in visual monotony. From a neuropsychological perspective, optimal lighting is that which supports the body’s natural rhythms, aligns with the tasks being performed, and ensures visual comfort, all of which contribute to positive mental states. Neuroscience-informed design integrates these insights holistically, combining natural and artificial light in a dynamic, intentional manner that nourishes both body and mind.

7.5 BIOPHILIA: NATURE IN THE BUILT ENVIRONMENT

Biophilia refers to the innate human affinity for nature and natural elements. In architecture, biophilic design aims to integrate nature—through vegetation, water, direct sunlight, external views, and organic forms—into the built environment in order to harness the restorative effects nature has on the human brain. A broad base of empirical evidence supports the beneficial impact of biophilic elements on psychological and physiological well-being. Visual contact with nature has been shown to reduce activation of the stress axis, as indicated by lower cortisol levels and blood pressure, while simultaneously eliciting positive emotions such as calmness and gentle fascination (Joye & van den Berg, 2011).

As mentioned before, a landmark study by Ulrich et al. (1991) demonstrated that hospital patients whose rooms had views of trees recovered more quickly and required less analgesic medication than those facing brick walls, marking a turning point in the scientific recognition of nature's therapeutic role in healing environments, and how the contact with natural elements can influence our well-being.

From a cognitive standpoint, the Attention Restoration Theory (Kaplan & Kaplan, 1989) posits that natural environments engage the mind through a form of effortless attention known as "soft fascination," allowing directed attention—used in cognitively demanding tasks—to recover from fatigue. Consequently, incorporating natural features into work or learning spaces can support cognitive renewal during breaks, enhancing subsequent focus and performance. For instance, Lee et al. (2015) found that employees with desk plants or views of landscaped areas reported lower mental exhaustion and greater job satisfaction compared to those in environments devoid of natural features.

Biophilia also contributes to emotional and social dimensions. Biophilic environments are typically described as more welcoming, relaxing, and inspiring, and they may even encourage more positive social interactions. In commercial settings such as restaurants and retail spaces, the presence of greenery and water features has been associated with increased dwell time and enhanced customer well-being (Joye et al., 2010). In educational settings, classrooms with views of green areas have been linked to reduced student stress levels and marginally better academic performance compared to those without windows or with barren urban views (Li & Sullivan, 2016).

However, the effectiveness of biophilia depends on the depth and quality of integration. A few potted plants in an otherwise artificial environment may have limited psychological impact, whereas more comprehensive strategies, such as green walls, landscaped courtyards, extensive use of natural materials like wood and stone, ample daylight, and biomorphic forms, tend to produce stronger effects on well-being, as can be observed in Figure 11.

Figure 11

Biophilic Design: Integrating Nature Through Forms, Materials, and Vegetation

Emerging findings in neuro-urbanism suggest that well-designed urban spaces, when interspersed with natural elements, may be equally or even more restorative than traditional green spaces. For example, Elsayed et al. (2024), using EEG data, observed that vibrant commercial streets in urban contexts produced higher levels of mental relaxation among young adults than tree-lined parks, challenging the notion that only “pure” nature is restorative. These insights suggest that biophilia can act synergistically with positive urban stimuli, such as art, social interaction, and perceived safety, to create optimised environmental experiences.

In conclusion, the biophilic principle within neuroarchitecture highlights that integrating nature into built environments is not merely an aesthetic or sustainability concern, but a vital strategy for promoting mental health, reducing stress, and strengthening emotional bonds with space. Designers should therefore actively seek opportunities to reconnect occupants with nature, visually, materially, or symbolically, as an integral component of architecture aimed at human flourishing.

CHAPTER 8. NEUROSCIENCE IN ACTION: INTERIOR DESIGN PROJECT EXAMPLES

In the ongoing pursuit of environments that promote both physical comfort and psychological well-being, architectural firms around the world have begun to distinguish themselves through specialisation in neuroarchitecture, biophilic design, and sustainable practices. Notable examples include NacLab, NBBJ, Gensler, and Perkins&Will (Matoso, 2022).

Based in Seattle, NacLab is a pioneering design studio that specialises in neuroarchitecture, biophilic integration, and sustainable environments. Their work consistently prioritises human-centred outcomes, particularly within healthcare and educational contexts.

As demonstrated in Figure 12, the James Baldwin Elementary School exemplifies how design can support cognitive performance, emotional well-being, and a sense of belonging. This is achieved through the strategic use of natural light, adaptable spatial configurations, biophilic elements, and carefully considered acoustic and colour schemes that enhance concentration and comfort. By addressing users' cognitive, emotional, and physiological needs, NacLab designs spaces that nurture creativity and promote lasting well-being, establishing the firm as a leading reference in neuroscience-informed architectural practice.

Figure 12

James Baldwin Elementary School - NacLab

NBBJ is a globally recognised architecture firm with studios in major international hubs. Its multidisciplinary approach, rooted in neuroscience, urban planning, and environmental psychology, is structured under the framework of Experience Design. Celebrated for innovative projects such as the Google and Samsung campuses in Silicon Valley and Amazon's iconic spheres in Seattle, the firm consistently applies neuroarchitectural strategies to improve user experience, spatial understanding, and engagement.

The American International University (AIU) in Kuwait City, presented in Figure 13, showcases this methodology through its emphasis on natural daylight, spatial fluidity, and environmental rhythm. The architectural layout enhances cognitive clarity and intuitive wayfinding, while visual access to nature supports emotional regulation and reduces stress. By encouraging both concentrated learning and social interaction, the design nurtures psychological well-being and strengthens the academic community.

Figure 13

American International University (AIU) Kuwait City – NBBJ

Founded in 1935, Perkins&Will has established itself as a global leader in architecture grounded in human-centred values and sustainability. With studios across multiple continents, the firm is widely recognised for implementing evidence-based design in corporate, commercial, and especially healthcare environments, and it is at the forefront of modern neuroarchitectural thinking. The *UChicago Medicine Crown Point* project exemplifies these principles.

As illustrated in Figure 14, the design encourages healing through abundant access to daylight and exterior views, intuitive circulation, and the integration of natural materials that convey warmth and safety. Colour is used intentionally to support emotional regulation and orientation. Soft, desaturated hues dominate clinical and transitional spaces to reduce stress, while slightly more saturated tones highlight key areas and improve spatial legibility. Waiting and consultation zones are carefully calibrated to promote calm, privacy, and trust. By aligning form, light, materiality, and chromatic design with the physiological and emotional needs of its users, Perkins&Will delivers healthcare environments that truly embody the goals of neuroscience-informed design.

Figure 14

UChicago Medicine Crown Point- Perkins&Will

Established in 1965, Gensler is an internationally acclaimed architecture and design firm with offices in over 50 cities. Its practice is defined by a rigorous integration of neuroscience, user experience, and environmental psychology, which informs projects across sectors such as education, corporate, and civic architecture. Gensler prioritises contextual responses over formal solutions, aiming to support human behaviour, engagement, and well-being through evidence-based strategies.

The Google at St. John's Terminal project in New York, shown in Figure 15, reflects these values in practice. The design leverages expansive natural light, open circulation paths, and organic materials to create a stimulating yet grounded workspace. Spatial zoning balances collaboration and privacy, while visual coherence and tactile variation help mitigate sensory fatigue. The careful orchestration of light, material, and programme contributes to a dynamic environment that not only accommodates the functional demands of a global tech headquarters but also nurtures psychological comfort and long-term occupational health.

Figure 15

Google at St. John's Terminal - Gensler

Analysing exemplary neuroscience-informed projects provides critical insights into the design strategies adopted by leading architects and designers. It is essential to assess how such design addresses environmental composition through elements such as form, colour, texture, lighting, and more, demonstrating how the relationship between the built environment and human experience can be consciously shaped and optimised.

Through the exploration of tangible applications that embody the principles of neuroarchitecture and evidence-based design, we can uncover the measurable impacts of these innovative strategies on human well-being. Such design projects not only serve as valuable sources of inspiration but also offer practical takeaways for creating environments that positively influence both mind and body. Moreover, case-based analysis can highlight the main challenges encountered throughout the design and development process, such as the integration of sustainable practices, harmonisation with natural surroundings, and adaptation to evolving user needs. Understanding these constraints is essential for refining future practice and advancing more responsive, evidence-based solutions.

This section of the dissertation initiates a focused investigation into the practical integration of neuroscience in built environments, revealing how such applications contribute to spaces that support emotional depth and psychological well-being. The analysis demonstrates how the interplay between neuroscience and design enhances user experience in meaningful and lasting ways.

8.1 TWO UNION SQUARE LOBBY / NBBJ

The renovation of the Two Union Square Lobby in Seattle, led by NBBJ, offers a compelling demonstration of how neuroscience-informed design can elevate both function and emotion within a large commercial setting (see Figure 16). Originally completed three decades ago, the building had undergone a series of incremental modifications that fragmented spatial continuity and rendered communal areas underutilised. In 2015, the building's owner issued a brief calling for a bold, renewed vision that would accommodate evolving organisational and cultural dynamics, including the rise of mobile and fluid work models (ArchDaily, 2019).

In response, NBBJ repositioned the public zones of the building with an approach centred on user experience. Contrary to typical strategies that prioritise maximum spatial efficiency, the design team focused on the creation of agile, human-centred environments that address the psychological and emotional needs of the occupants.

Figure 16

Interior view of Two Union Square Lobby

As illustrated in Figure 17, circulation routes are now articulated through gently curving walls and integrated social pockets that encourage spontaneous interaction. Rather than rigidly prescribing uses, the designers modulate ceiling height, acoustic rhythm and floor texture to suggest zones for work, rest and collaboration within a single, legible volume, an approach that maintains intimacy even in a 56-storey skyscraper context. The interior's fluidity is also enhanced through circular seating layouts and the organic geometry of ceiling forms, which encourage movement and interaction. Through careful attention to spatial proportion and human scale, the lobby offers a sense of enclosure and comfort without sacrificing openness (ArchDaily, 2019).

Figure 17

Interior view of Two Union Square Lobby

As seen in Figure 17, transparent curtains and extensive glazing foster both interpersonal connection and visual access to the external landscape, supporting the human need for connection with the natural world. As established in the literature (Valdez & Mehrabian, 1994; Bower et al., 2022), such visual and tactile stimuli have a measurable impact on neural activity and emotional states, further validating the project's design logic.

Material and chromatic choices further reinforce these intentions (Figure 18). A restrained palette of stone, wood and warm neutrals promotes calm while supporting spatial coherence. Subtle textural contrasts invite multisensory engagement without visual overload, aligning with findings that tactile variety can lower cortisol and enhance mood (De Paiva, 2019).

Figure 18

Interior view of Two Union Square Lobby

The use of natural materials—wood, stone, and neutral tones—combined with soft, organic lines and varied textures creates a multisensory experience that promotes tranquillity and psychological safety. These are foundational components of biophilic design, which has been shown to reduce cortisol levels and improve emotional regulation.

Lighting strategy completes the neuroarchitectural triad. Expansive glazing delivers circadian-supportive daylight, while concealed luminaires balance brightness gradients after dusk, preserving biological coherence and aiding way-finding (Figure 19). Similarly, the lowered wooden ceilings in the elevator lobbies and panoramic external views offer both grounding and orientation, reinforcing the importance of spatial familiarity and environmental coherence. Together, these measures transform the lobby from a transit space into a cognitively clear, emotionally supportive urban living-room.

Figure 19

Interior view of Two Union Square Lobby

The Two Union Square Lobby renovation by NBBJ exemplifies the synergy between neuroscience and design. By embedding neuroscience insights into every layer of the design. From spatial configuration and materiality to lighting and sensory experience, the project transcends the functional demands of a corporate lobby.

In order to illustrate how the principles of neuroarchitecture are applied in contemporary practice, this section presents a critical synthesis of the design strategies implemented in the Two Union Square Lobby project. The analysis is structured according to key neuroarchitectural variables, highlighting how each of these elements contributes to the creation of a space that supports psychological well-being, emotional balance, and cognitive performance:

Colour

- A restrained, natural palette dominated by soft neutrals and warm tones was employed to evoke calmness and reduce cognitive overstimulation.
- The chromatic consistency supports visual coherence, promoting spatial legibility and a sense of order.

Form and Proportion

- The space features generous ceiling heights and clean, geometric lines, contributing to a sense of openness and cognitive clarity.
- Harmonious proportions throughout the lobby promote a balanced perception of scale, reducing stress and enhancing user comfort.

Textures and Materials

- Natural materials such as stone, wood, and metal were selected for their tactile richness and sensory grounding.
- The interplay between smooth and textured surfaces stimulates sensory engagement without overwhelming the user.

Lighting

- A sophisticated combination of natural and artificial lighting supports circadian alignment and mood regulation.
- Lighting design also enhances spatial depth and highlights material qualities, reinforcing perceptual richness.

Biophilia

- Subtle biophilic elements, such as natural materiality and organic patterns, were integrated to foster a connection with nature.
- Visual access to greenery and external views contributes to stress reduction and mental restoration.

The overall design promotes a multisensory dialogue with the natural world, supporting emotional balance and cognitive function.

8.2. THE UNIVERSITY OF VIRGINIA, UNIVERSITY HOSPITAL EXPANSION / PERKINS&WILL

The expansion of the University Hospital at the University of Virginia, designed by the renowned architectural firm Perkins&Will, represents a benchmark in the application of neuroarchitecture and evidence-based design (EBD) within the context of healthcare architecture. With a human-centred and sustainability-driven principals, the project seeks to foster positive emotional and physiological experiences for patients, their families, and medical staff, while meeting high environmental performance standards (ArchDaily, 2021).

Through its commitment to well-being, biophilic integration, flexibility, and empathetic spatial organisation, the design articulates a clear response to the evolving nature of healthcare environments. A welcoming semicircular entrance (Figure 20) immediately signals empathy and inclusion, leading to an atrium where soaring ceilings and circular skylights deliver an abundance of diffuse daylight.

At the heart of the architectural narrative is the symbolic semicircular entryway, extending outward like welcoming arms. This gesture immediately sets a tone of care and inclusivity, which is reinforced upon entering the spacious atrium, where soaring ceilings, expansive glazing, and circular skylights allow for the generous diffusion of natural light.

Figure 20

Interior view of The University of Virginia, University Hospital Expansion

This not only enhances spatial orientation and comfort for staff but also aligns with findings in environmental psychology that associate daylight exposure with reduced stress and improved cognitive function. Particular attention has also been given to the needs of younger patients. As shown in Figure 21, the paediatric check-in and waiting area is distinguished by playful features such as an interactive wall depicting the Shenandoah Valley, embedded animal figures on tracks, organic ceiling lights, and bright yellow child-sized sofas. These elements collectively foster a sense of safety, curiosity, and engagement, which are critical in reducing procedural anxiety and enhancing patient cooperation.

The architectural form further supports privacy and dignity, with curved walls in the inpatient tower preventing direct lines of sight between rooms and the adjacent hospital. These curves improve visibility for medical staff while shielding patients from unnecessary exposure, offering a sense of enclosure that enhances both clinical efficiency and emotional comfort.

Figure 21

Interior view of The University of Virginia, University Hospital Expansion

Biophilic design is seamlessly incorporated into the project, bringing daylight and outdoor views into typically enclosed areas through glazed passages. Even deep surgical corridors gain borrowed daylight and external views via a glazed connective spine (Figure 22), a move correlated with lower staff stress and improved patient orientation.

Figure 22

Interior view of The University of Virginia, University Hospital Expansion

Adaptability, another core tenet of evidence-based design, was demonstrated during the COVID-19 pandemic when 84 rooms across three floors were seamlessly converted into negative pressure isolation units. This capacity for functional transformation highlights the importance of flexible design in creating resilient healthcare infrastructure capable of responding to public health emergencies (ArchDaily, 2021).

The University of Virginia Hospital expansion exemplifies how a thoughtful methodology for applying evidence-based design can elevate healthcare environments beyond functional performance. It demonstrates that healing spaces must not only respond to medical needs but also nurture the emotional, cognitive, and sensory dimensions of human experience. The analysis follows a framework to reveal how Perkins&Will orchestrated a space that is resilient, empathetic, and profoundly human:

Colour

- A palette of light woods, soft whites and muted earth tones establishes visual calm while subtly signalling cleanliness and safety.
- Accents of warm yellow and pale blue in paediatric areas provide positive distraction for younger users.

Form & Proportion

- Curvilinear walls shield patient rooms from direct sight-lines, supporting privacy and perceived sanctuary.
- A 28-foot-high atrium and generous glazing enlarge perceived space, lowering stress biomarkers associated with confinement.

Textures & Materials

- Tactile wood ceilings, stone flooring and metal fins balance softness with hygienic robustness, encouraging sensory grounding without visual clutter.

Lighting

- Twelve-foot circular skylights and full-height windows deliver diffuse daylight that helps entrain circadian rhythms and reduce anxiety.

Biophilia

- Landscaped entry courts, interior green roofs and continuous outward views reconnect occupants with natural cycles, accelerating recovery and supporting staff respite.

8.3 PINTEREST MEXICO CITY OFFICE / GENSLER

Gensler's Pinterest Mexico City headquarters demonstrates how cultural identity and neuroscientific insight can together cultivate creativity and well-being. Entry and reception areas, shown in Figure 23, employ a colour narrative that references Mexican craft traditions while stimulating the ventral striatum. This project harmoniously blends Pinterest's global brand identity with the rich cultural tapestry of Mexico, resulting in an environment that fosters creativity, well-being, and a sense of belonging (Gensler, n.d.).

Figure 23

Reception area of Pinterest Mexico City office

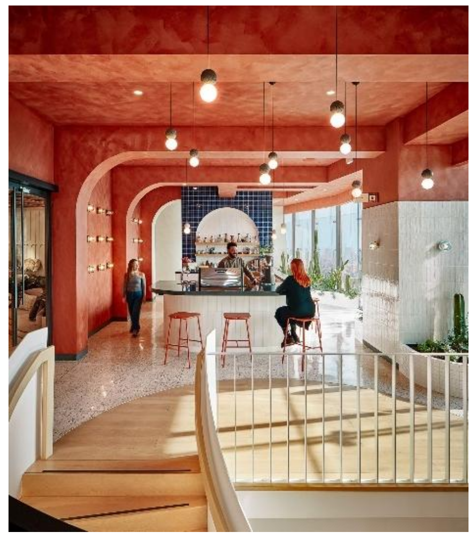
Central to the design is the concept of a sensory journey, inspired by the effect of a kaleidoscope, which guides users through various collaborative and recreational spaces that celebrate Mexico's sights and traditions. For instance, the "Sanctuary of Fireflies" features a spiral staircase (Figure 23) that evokes the country's natural beauty, while the Mezcal Bar, shown in Figure 24, with its terracotta tones, serves as a cultural meeting point. The Café offers a retreat inspired by the waves of Mexico's northern beaches, and cenote-inspired spaces provide areas for concentration and reflection.

From a neuroarchitectural standpoint, the combination of natural materials, organic forms and culturally resonant motifs engages multisensory perception, enhancing cognitive performance while reducing stress. Varied lighting conditions, ranging from the dappled glow of the firefly stair to the daylight-washed double-height lounges (Figure 24 and 25) support circadian alignment and task specificity.

As seen in Figure 24, a recurring motif of softly curved arches frames thresholds and nooks throughout the floor plate. These archways not only reference colonial arcades and vernacular courtyard forms, but they also soften the visual field, promoting a sense of refuge and continuity of movement. From a neuroscience perspective, curved geometries facilitate smooth eye tracking and reduce cognitive load, thereby supporting focused attention and emotional comfort.

Figure 24

Pinterest Mexico City office



The office's layout promotes movement and exploration, with open collaboration areas, quiet zones, and social spaces strategically distributed to encourage spontaneous interactions and personal retreats. This spatial diversity reflects EBD principles, which advocate for environments that accommodate a range of user needs and preferences, thereby improving satisfaction and productivity.

A layered approach to biofilia permeates the interior. Beyond potted species, suspended planters and trailing greenery weave through acoustic baffles over bench seating, as seen in Figure 26, creating verdant canopies that enhance air quality and visual shelter.

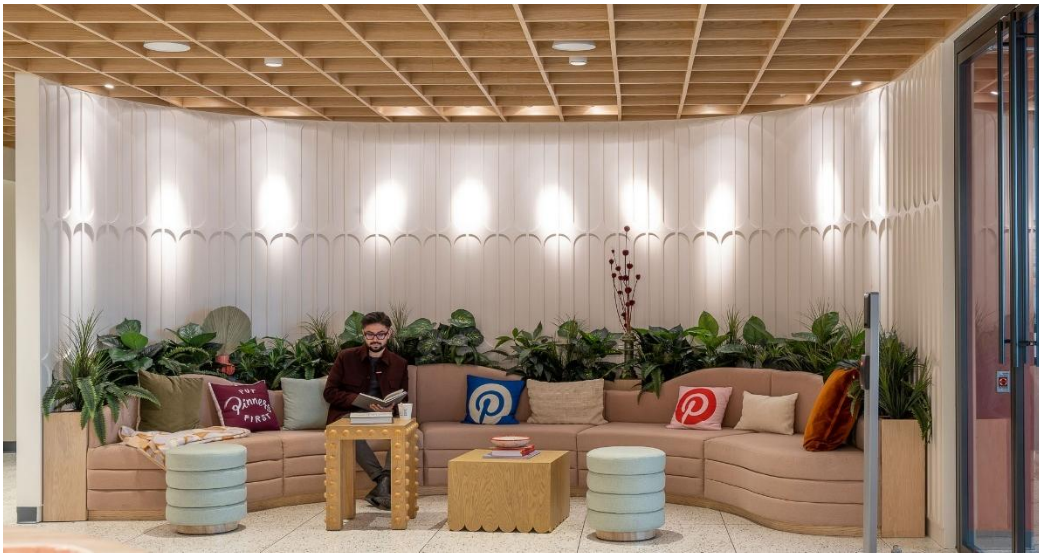
In terms of textures, the design juxtaposes hand-painted ceramic tiles and rough-cast stucco with a rich palette of textiles, as observed in Figure 25. Lightweight cotton voile drapes subtly billow with HVAC airflow, introducing kinetic texture and softening hard edges (Figure 24)

Figure 25

Pinterest Mexico City office

Figure 26

Pinterest Mexico City office



Furthermore, the integration of local art, traditional crafts, and symbolic elements throughout the office not only reinforces cultural identity but also provides visual stimuli that can enhance memory and creativity. By embedding narratives and meanings into the physical space, the design fosters a deeper connection between users and their environment, a core tenet of neuroarchitecture.

The Pinterest Mexico City office stands as a testament to the power of design in shaping human experience. Through the thoughtful application of neuroarchitectural and evidence-based design principles, Gensler has created a workspace that is functional and aesthetically pleasing and also emotionally enriching and culturally meaningful.

To demonstrate how workplace design can weave cultural identity with neuroscientific insights, the following synthesis assesses Pinterest's Mexico City headquarters through the same five-variable lens. The project exemplifies how sensory richness and local symbolism can jointly enhance creativity, social cohesion and cognitive renewal:

Colour

- A saturated spectrum (terracotta) Mexican craft tradition, stimulating creative ideation.
- Zone-specific palettes aid task-based orientation and memory encoding.

Form & Proportion

- Double-height stair interconnections and playful archways emulate urban courtyard scales, encouraging incidental encounters and social bonding.

Textures & Materials

- Hand-painted tiles, carved wood screens, locally sourced clay vessels and textiles provide multisensory cues that anchor cultural belonging and tactile engagement.

Lighting

- Floor-to-ceiling glazing maximises daylight and panoramic city views, enhancing alertness and mood regulation.
- Energy-efficient fixtures achieve delivers visual comfort without glare.

Biophilia

- Indoor planters, create subtle nature connections that lower sympathetic arousal.
- Elevated vistas of the surrounding urban canopy offer prospect-refuge benefits, supporting cognitive restoration.

By integrating nuanced strategies across these variables, the Pinterest Mexico City office exemplifies how evidence-based design can craft a workplace that is neurologically attuned, culturally resonant and operationally effective.

CHAPTER 9. SYNTHESIS AND PRACTICAL GUIDELINES FOR HUMAN-CENTERED DESIGN BASED ON NEUROSCIENCE

The integration of neuroarchitectural principles is essential to advancing design practices, providing a more rigorous and empathetic approach to spatial composition. Nevertheless, it is crucial to acknowledge that human perception is inherently subjective. Each individual's experience is shaped by a unique sociocultural background and personal history. How, then, can findings from neuroarchitecture be applied in a field that is so deeply rooted in subjectivity? The aim is not to impose prescriptive rules or standardised design guidelines, but rather to foster an understanding of human experience in relation to the built environment—enabling designers to positively influence spatial perception through informed choices.

> Architecture communicates with people through that which is already known to them in their habits and everyday life. The likelihood of individuals experiencing specific emotions in their interaction with architecture increases when designers incorporate symbols familiar to that society or community, which carries a particular cultural repertoire. (Villarouco et al., 2021, p. 112)

In recent decades, the evolution of neuroscience and environmental psychology has equipped architects and designers with tools to create built environments that actively contribute to human health and well-being. The field of neuroarchitecture, in particular, bridges the gap between brain science and spatial design, allowing professionals to develop evidence-based strategies that prioritise not only functional needs but also emotional and cognitive support. This chapter outlines key design guidelines that emerge from scientific research and the analysis of reference design projects, offering practical recommendations for interior projects that place human well-being at the centre of their agenda.

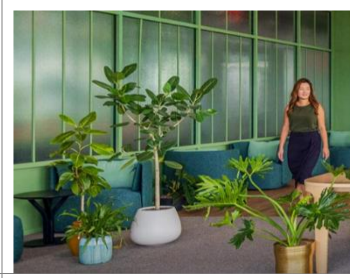
The neuroscientific evidence reviewed in this dissertation culminates in design strategies intended to assist architects and interior designers in shaping environments that foster health, well-being, and cognitive performance. These strategies emerge from a rigorous synthesis of empirical studies on colour, form and proportion, texture and materials, lighting and biophilic integration, and they are tempered by theoretical frameworks drawn from environmental psychology and neuroarchitecture. Collectively, they translate laboratory findings into actionable guidance for professional practice.

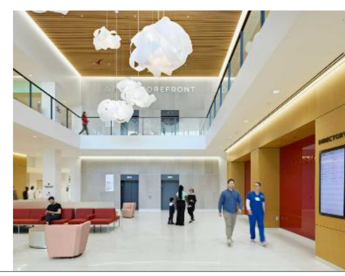
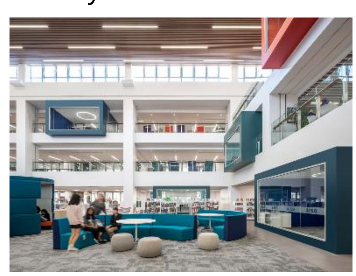
Yet it is crucial to recognise that such guidance cannot be codified into universally prescriptive rules. Spatial experience is inexorably mediated by cultural meaning, individual biography, and situational exigency. Consequently, each design intervention demands a nuanced, context-sensitive reading of its users, functions, and socio-environmental conditions.

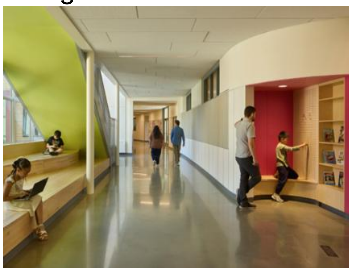
These strategies should therefore be viewed as a set of flexible guiding principles, one that supports designers in formulating hypotheses, structuring post-occupancy evaluations, and iteratively refining their work. Finally, the rapid evolution of neuroscience obliges practitioners to adopt a stance of critical curiosity. Design decisions grounded in today's best evidence must remain open to revision as new discoveries emerge regarding sensory processing, affective response, and human–environment interaction. In this sense, the strategies presented here are less an endpoint than a provisional map for an ongoing research-informed design process, one in which creative inquiry and empirical validation continuously inform one another.

Table 1

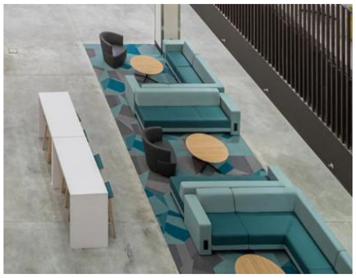
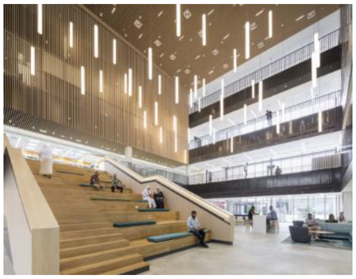
Strategies for Integrating Neuroscience into Human-Centred Design

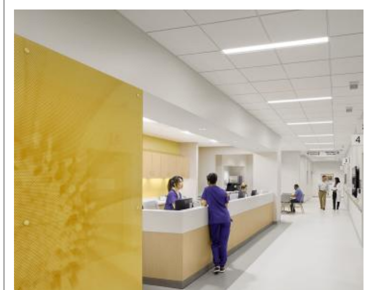
Design Variable	Documented Neuro /Behavioral Effects	Evidence-Based Design Strategies	How it is applied/Examples
		COLOUR	
Cool tones (blue, green)	• Increase parasympathetic activity (calm, relaxation) • Stimulate creativity and abstract reasoning • Reduce negative affect when paired with warm lighting;	• Apply in creative settings • Combine with slightly warm lighting (2700–3500K) • Use in waiting rooms or recovery areas	• Healing Spaces:  • Creative settings: 
Warm tones (red, orange)	• Elevate physiological and cognitive arousal • May decrease perceived environmental control • Enhance detail-oriented tasks • Increase agitation when combined with warm light	• Use as accent in energising areas • Avoid in rest areas with warm lighting • Apply to highlight focal zones or architectural details	• Energising areas/ focal zones: 

Design Variable	Documented Neuro /Behavioral Effects	Evidence-Based Design Strategies	How it is applied/Examples
COLOUR			
Neutral and soft hues	• Associated with calming environments • Support emotional balance and visual comfort	• Use as base palette in residential, healthcare, educational spaces and rest areas. • Create a backdrop for sensory or functional focal elements	• Backdrop for other elements/rest areas:  • Sensory elements/rest areas: 
Highly saturated colours	• Stimulating when overused • May provoke tension or visual fatigue	• Limit use to transitional or short-stay spaces • Avoid as a main colour in bedrooms, therapy rooms, or medical facilities	• Used in medical facility only in a short-stay area, combined with neutral background as a focal point: 
Contrast between colour and lighting	• Affects emotional state and cognitive performance • Blue with cool light boosts creativity and reaction • Blue with warm light lowers negative mood	• Balance lighting temperature with wall colour • Employ subtle contrasts to support mood and performance	• Used in educational spaces, blue with cool light enhances creativity and reaction: 

Design Variable	Documented Neuro /Behavioral Effects	Evidence-Based Design Strategies	How it is applied/Examples
COLOUR			
Symbolic/ natural colour associations	• Blue evokes sky, green evokes nature, earth tones suggest stone/clay • Stimulate autobiographical memory and spatial grounding	• Use biophilic palettes to emulate natural environments • Tailor colour schemes to space function and cultural context	• Used to emulate natural settings (Sky/water):  • Used as a cultural meeting point with terracotta tones, as seen in Mexico: 
Colour and memory	• Enhances memory recall • Objects are perceived in prototypical colours even in greyscale	• Use familiar and culturally resonant colours to promote emotional comfort • Reinforce spatial recognition with consistent chromatic cues	• Used to define and reinforce spatial zoning through colour cues: 
Colour as non-verbal language	• Shapes perception through emotional and cultural association • Communicates mood and meaning	• Apply culturally informed colours aligned with space function • Support intuitive navigation through strategic colour placement	• Facilitates wayfinding using strategic colour placement: 

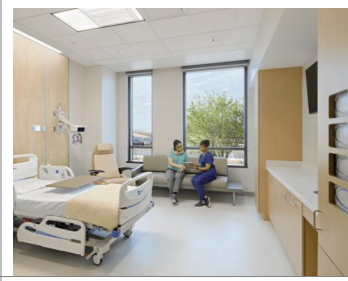
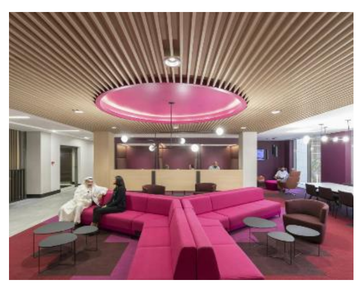
Design Variable	Documented Neuro /Behavioral Effects	Evidence-Based Design Strategies	How it is applied/Examples
FORM AND PROPORTION			
Curved forms	• Perceived as more aesthetically pleasing • Associated with activation in brain areas linked to safety and comfort • Reduce (lower perceived threat)	• Use curved furniture, arches, or rounded walls to promote psychological ease • Sense of warmth and relaxation	• Rounded elements (walls, ceiling, layout and furniture) used in resting areas: 
Angular forms	• Increase amygdala activity • May evoke alertness, tension, or subtle discomfort	• Use sparingly in high-stress environments • Soften angular elements with textures or lighting	• Angular forms used in attention and short-stay area, softened with lighting and texture: 
Open-plan layouts	• Activate prefrontal cortex areas linked to reward and exploration • Perceived as more freeing and engaging	• Use open layouts in social and creative spaces • Minimise unnecessary partitions	• Open-plan layout used to enhance fluidity in social area: 
Enclosed spaces	• Curved or narrow paths and low ceilings trigger anticipatory sensorimotor brain responses • Form guides spatial navigation and emotional readiness	• Use gentle curves and spatial flow to enhance user engagement and orientation	• Curved corridor enhances spatial flow and reduces discomfort from low ceilings: 

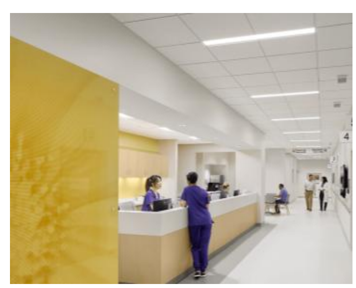
Design Variable	Documented Neuro /Behavioral Effects	Evidence-Based Design Strategies	How it is applied/Examples
FORM AND PROPORTION			
Scale and ceiling height	• Higher ceilings: stimulate abstract thinking and openness • Lower ceilings: increase focus, but may limit perceived freedom • Influences emotional tone and cognitive efficiency	• Match ceiling height to function: high for brainstorming, low for focus tasks	• High ceilings for social and creative areas:  • Low ceilings to support focus and attention: 
Overly expansive spaces	• Can induce discomfort or disorientation • Risk of overstimulation and reduced sense of safety	• Use visual zoning (furniture, rugs, lighting) to structure space • Apply warmer tones or texture to increase intimacy	• Use visual zoning through colour and texture to structure space:  • Apply warm materials like wood to enhance intimacy: 

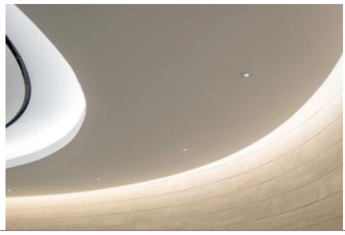
Design Variable	Documented Neuro /Behavioral Effects	Evidence-Based Design Strategies	How it is applied/Examples
FORM AND PROPORTION			
Overly confined spaces	• May lead to anxiety or reduced cognitive performance	• Bright lighting and reflective materials to expand perceived size • Light ceiling colours to increase vertical perception	• Bright lighting and reflective surfaces to expand perceived space, and white ceilings to enhance vertical perception: 
Perceived height and volume (visual manipulation)	• Perceptual adjustments can alter emotional impact • Affects sense of intimacy vs. openness	• Use darker ceiling tones for intimacy, lighter tones for openness • Vertical lines to enhance perceived height • Horizontal elements to stretch space width-wise	• Vertical lines used to enhance the perception of height, while darker ceiling colour create a sense of intimacy: 

Design Variable	Documented Neuro /Behavioral Effects	Evidence-Based Design Strategies	How it is applied/Examples
TEXTURES AND MATERIALS			
Natural materials	• Reduce heart rate and skin conductance • Increase parasympathetic activity (relaxation) • Lower muscle tension and fatigue • Promote cognitive load relief and stress recovery	• Use exposed wood in ceilings, walls, and furniture • Prioritise tactile access to natural materials • Apply stone or organic surfaces in focal areas	• Exposed wood applied to the ceiling:  • Stone surfaces (counter and floor) 
Textured surfaces	• Smooth, shiny and monotonous surfaces reduce alpha wave activity (linked to rest) • Natural textures promote “soft attention” and reduce stress • Fractal complexity stimulates the brain pleasantly	• Integrate medium-complexity fractal textures (wood grain, linen) • Avoid excessive smooth/ reflective finishes in rest areas • Include textiles and surfaces with tactile variation	• Wood furniture and different textiles combined:  • Fractal textures and variation: 

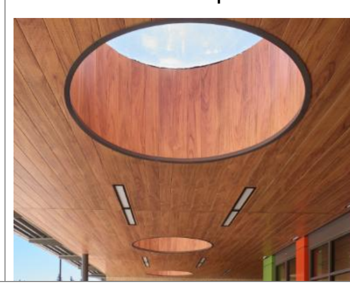
Design Variable	Documented Neuro /Behavioral Effects	Evidence-Based Design Strategies	How it is applied/Examples
TEXTURES AND MATERIALS			
Visual texture without tactile interaction	• Passive visuals may not engage emotional or memory centres • Minimal impact if no direct interaction or user relevance	• Prioritise multisensory engagement (touch, sight, scent) • Combine visual patterns with lighting changes and tactile opportunities	• Textiles applied to the ceiling engage users through visual interest and subtle movement:  • Visual patterns on ceilings and walls, combined with tactile elements like carpets and textured furniture, to enhance sensory engagement: 
Biophilic integration	• Stimulates rest response and improves physiological rhythm • Reduces sympathetic nervous system activity (stress) • Subtle sensory stimulation	• Use wood, bamboo, linen, clay where regular human contact occurs • Introduce biophilic design layers (plants + wood + textures) • Use lighting to enhance texture perception	• Light used to enhance texture perception:  • Biophilic design applied layers: 

Design Variable	Documented Neuro /Behavioral Effects	Evidence-Based Design Strategies	How it is applied/Examples
TEXTURES AND MATERIALS			
Temperature and material perception	• Cold materials feel impersonal • Warm materials enhance comfort and human connection	• Avoid overuse of metal/glass in high-stress or social zones • Use warm-toned or thermally pleasant materials in seating and touch points	• Use of warm tone materials, (colour red) in seating zones, and thermally pleasant (wood): 
Synthetic materials (plastic, glass, metal)	• Associated with impersonal, less engaging sensory response • May contribute to discomfort or cognitive fatigue if overused	• Use only where functional (hygiene), and balance with natural elements • Apply warm lighting or textured contrast to humanise sterile surfaces	• Use of warm materials like wood to balance the sterility of hospital room surfaces: 
Material coherence and pattern recognition	• Incoherent material mix increases cognitive load • Harmonised texture use enhances spatial identity	• Repeat select textures strategically (same wood tone across surfaces) • Avoid chaotic mixing of unrelated materials	• Repeated textures, such as wood on walls and ceiling and textiles on seating areas, create coherence and comfort: 

Design Variable	Documented Neuro /Behavioral Effects	Evidence-Based Design Strategies	How it is applied/Examples
LIGHTING			
Natural daylight	• Improves mood, alertness, and circadian rhythm • Reduces depression symptoms • Enhances productivity and sleep quality	• Maximise window size and placement • Prioritise daylight exposure, especially in morning • Ensure access to outdoor views	• Emphasis on natural lighting, with the ceiling design allowing greater use of daylight from existing windows: 
Morning sunlight exposure	• Synchronises circadian rhythms • Increases daytime alertness • Promotes night-time melatonin production	• Orient workspaces and rest areas to the east when possible • Use transparent blinds to filter rather than block morning light	• Strategically placing work-spaces to maximise natural light use: 
Cool, high-intensity lighting	• Enhances cognitive performance • Increases alertness • May provoke stress if overused	• Use in workspaces, schools, hospitals during the day • Avoid at night to prevent melatonin suppression	• Cool and intense lighting in medical facilities: 

Design Variable	Documented Neuro /Behavioral Effects	Evidence-Based Design Strategies	How it is applied/Examples
LIGHTING			
Warm, dim lighting	• Promotes relaxation • Supports melatonin production • Enhances reflection and emotional comfort	• Apply in rest areas, bedrooms, lounges after dusk • Use warm-toned LEDs or dimmable lighting systems	• Warm-toned LEDs in rest areas: 
Personal control of lighting	• Enhances sense of autonomy • Increases satisfaction and comfort • Improves task engagement	• Provide adjustable luminaires or smart control interfaces • Allow users to adjust intensity/colour temperature	
Human-centric (integrative) lighting	• Supports circadian alignment • Balances stimulation and relaxation depending on time of day	• Program lighting systems to follow diurnal cycles • Bright/cool lighting in the morning, warm/dimmed light in evening	
Lighting quality (shadows, contrast)	• Reduces eye fatigue • Improves perception and focus • Supports mental clarity	• Ensure even luminance and soft shadows • Highlight textures and architectural forms with directional lighting	• Soft shadows that highlight textures and materials: 
Lighting and spatial perception	• Affects legibility and engagement • Influences sense of spaciousness and depth	• Combine diffuse and accent lighting • Use light to define zones and hierarchies in space	• A skylight distributes light to the centre of the space, defining the main lobby area: 

Design Variable	Documented Neuro /Behavioral Effects	Evidence-Based Design Strategies	How it is applied/Examples
BIOPHILIA			
Views of nature (trees, greenery)	• Lowers cortisol and blood pressure • Promotes emotional calm and soft fascination • Accelerates healing in clinical settings	• Prioritise windows with natural views • Position workstations and patient beds to face greenery	• Views of nature in a medical facility to promote calm and improve the healing process: 
Natural elements indoors (plants, water)	• Enhances mood and job satisfaction • Reduces mental fatigue and stress • Increases social positivity and dwell time	• Add desk plants, indoor water features, and indoor gardens • Use in offices, retail, restaurants	• Used of plants in office spaces to reduce stress: 
Natural materials (wood, stone)	• Reinforces emotional connection to place • Triggers familiarity and biophilic responses	• Use natural materials prominently in finishes, furniture, and tactile surfaces • Avoid artificial imitations that lack sensory depth	• Combination of different natural materials, such as stone, wood, clay, fibres and textile: 
Green walls and courtyards	• Stronger restorative and affective impact than isolated plants	• Implement vegetated facades or internal courtyards with dense planting • Combine with natural lighting and water movement	• Indoor garden combined with natural lighting: 

Design Variable	**Documented Neuro /Behavioral Effects**	**Evidence-Based Design Strategies**	**How it is applied/Examples**
BIOPHILIA			
Biomorphic forms and organic shapes	• Stimulate gentle fascination and reduce stress	• Incorporate flowing, nature-inspired forms in furniture, lighting, or layout • Avoid excessive rigidity in geometry	• Flowing forms used in the volumetry, ceiling, and lighting:  •Fluidity in forms and space geometry: 
Natural daylight in biophilic settings	• Supports circadian rhythm • Enhances perceived connection to outdoors	• Integrate large windows and skylights in biophilic zones • Use transparent materials where privacy permits	• Large windows and use of transparent materials:  • Use of materials and forms to highlight the skylight and, consequently, the connection with the outdoor space: 

Design Variable	Documented Neuro /Behavioral Effects	Evidence-Based Design Strategies	How it is applied/Examples
BIOPHILIA			
Educational settings with green views	• Lowers student stress • Slight improvement in academic performance	• Ensure classrooms have outdoor green views or incorporate internal biophilic design	• In the absence of an outdoor view, biophilic design elements such as nature-inspired shapes and colours are applied:  •Green view and curved furniture: 
Comprehensive biophilic strategy	• Stronger cumulative impact on well-being • More effective than token plant additions	• Combine vegetation, natural materials, light, and spatial rhythm • Avoid superficial additions without sensory integration	• This example combines vegetation, natural materials (wood), natural light, spatial rhythm, and fluid forms: 

Beyond the well-established design variables of colour, form, texture, light, scale and the neuroscientific findings associated with them, creating genuinely *human-centred* environments demands attention to cultural, phenomenological and ethical dimensions that shape spatial experience. Cognitive-neuroscience research indicates that environmental variation re-energises the hippocampus and prefrontal cortex, thereby mitigating mental fatigue;

consequently, spaces must afford seamless movement between focused work, social interaction and rest. Interior layouts should provide a gradient of atmospheres, from secluded, low-stimulus niches to open, collaborative zones, enabled through movable partitions, modular furniture and adaptive lighting.

Functional flexibility, however, is only a starting-point. Places imbued with cultural resonance and symbolic meaning strengthen identity, belonging and emotional safety, because familiar visual cues activate memory networks and affective centres in the brain (Bower et al., 2022). Cultural relevance emerges when local communities participate in the design process, when vernacular materials are specified and when artistic elements reflect regional narratives. Emotional resonance intensifies as users recognise their own stories and values inscribed in the environment.

At a deeper level, phenomenological design reminds us that space is apprehended multisensorially: movement, sound, temperature, smell and light interweave in a *sensory choreography* that summons memories and moods. Gradual transitions of shadow, gentle thermal shifts, natural soundscapes and subtle olfactory cues anchor the body in the present, nurturing a profound sense of belonging and presence.

The intersection of neuroscience and phenomenology thus offers a powerful field of practice. A methodologically rich, empathic briefing phase must exceed the routine collection of functional requirements, adopting a neuro-phenomenological stance that explores users affective landscapes—what makes them feel safe, inspired, focused or soothed. Semi-structured interviews, mood boards, guided visualisations and experiential storytelling can surface sensory and symbolic needs that are seldom articulated explicitly. The briefing becomes a co-creative journey in which the client is an active partner, shaping the spatial expression of well-being.

Evidence-based design, therefore, does not displace intuition; it enlarges it. When scientific insight and lived experience are woven together, the built environment becomes more than shelter for the body: it evolves into a medium that nourishes mind and spirit, addressing the full spectrum of human needs, practical, aesthetic, sensory, emotional and existential.

DISCUSSION

Reflecting on the findings of this dissertation, it becomes evident that applying neuroscience in spatial design is both promising and challenging. On one hand, the evidence gathered on elements such as colour, form, lighting, texture and biophilia suggests tangible strategies for enhancing well-being in interior spaces. On the other hand, neurodesign remains a young and evolving field – many of the studies informing these strategies are relatively recent and may be supplanted by clearer evidence as research progresses. In fact, the concept of neuroarchitecture itself only emerged in the past two decades, integrating neuroscience and design to fulfil human well-being needs across cognitive, emotional, physical and social domains. As such, today's conclusions must be viewed as provisional. Designers and researchers alike should adopt a stance of critical curiosity, remaining open to new discoveries and prepared to revise practice in light of fresh evidence file. Keeping up-to-date with published research, from peer-reviewed studies to systematic reviews, as well as following influential professionals and organisations in this domain, is not a mere academic exercise but a practical necessity. The rapid evolution of neuroscience means that what we consider "best practice" today could be refined tomorrow, so an ongoing commitment to learning is crucial for anyone applying these insights in design file.

Another important consideration is the practical reality of implementing research insights in day-to-day design practice. Most interior designers do not have in-house labs or research teams; limitations of time, budget and expertise make it difficult to conduct original neuroscience research for every project. This research-practice gap is widely acknowledged: evidence-based design is still not common practice in design and architecture, and bridging this gap requires changes in how knowledge is disseminated and applied. High-quality neuroscientific studies can be complex, scattered across disciplines, and not easily digestible, which poses a challenge for practitioners who "don't know where to look" or how to translate findings into design decisions. It is therefore essential that designers make use of credible, peer-reviewed research that has been distilled into accessible guidelines or frameworks (such as the ones synthesised in this work). By consulting reliable sources, for example, meta-analyses, systematic reviews, or position statements from neuroscience-for-design organisations, designers can ground their choices in solid evidence rather than in trends or intuition alone. At the same time, critical thinking is essencial: even good research should be evaluated for relevance to the specific design context. In practice, evidence-based guidelines are most effective when treated not as rigid rules but as tools to inform creative decision-making file. Designers should feel encouraged to consult evidence proactively, while also applying their professional judgement to adapt that evidence to the project at hand.

Moreover, this discussion would be incomplete without emphasising the inherent subjectivity of spatial experience. Any interior space is ultimately experienced through the lens of individual users, each shaped by unique personal histories, neurodiversity, cultural backgrounds and social contexts. What evokes calm in one person may provoke discomfort in another; a colour imbued with positive cultural symbolism for some may carry neutral or negative connotations for others. Therefore, neuroscience-informed design must always be moderated by an understanding of *for whom* a space is being designed. Designers are urged to approach each project as a unique case study in human experience, using neuroscientific insights as hypotheses to be tested and adjusted. One practical way to operationalise this is through a “neurobriefing” with end users or clients at the outset of a project. A neurobriefing involves an in-depth consultation focusing on users’ sensory preferences, aversions, and any psychological or emotional cues that they associate with comfort or stress in environments. By identifying these perceptual and cognitive cues early, the designer can tailor strategies. For example, emphasising certain colours, adjusting lighting dynamics, incorporating particular textures or nature elements, to align with the user’s unique profile. Such a user-centred, *neuro-informed* briefing process ensures that the general principles derived from research are translated into specific, meaningful design decisions for that context. It also acknowledges that cultural and social nuances must guide the application of neuroscientific principles. Ultimately, recognising subjectivity in design means valuing empathy and personalisation alongside empirical evidence. Neuroscience can tell us about average human responses to spatial stimuli, but the designer must still interpret how those stimuli will likely interact with the particularities of their users.

It is also important to acknowledge the scope and limitations of this dissertation itself. The field of interior design is broad, and not every environmental variable could be explored within one study. This work has focused on several key design elements. Notably visual factors (such as colour, form/proportion and lighting), tactile and material qualities, and biophilic integration, because these are areas where neuroscientific research is relatively robust or emerging. Other crucial aspects of interior environments, however, were beyond the scope of the current research. Acoustics, for example, play a significant role in human well-being and cognitive performance, as do factors like thermal comfort, air quality, spatial layout, and furniture ergonomics. These were not discussed in depth here, not due to lack of importance, but to maintain a clear focus on the variables most directly addressed by contemporary neuro-design studies. Future research and practice would do well to investigate these additional variables through a neuroscientific lens, for instance, exploring how soundscapes affect stress hormone levels, or how indoor air quality might influence cognitive clarity and mood. Likewise, while this dissertation drew on examples of interior projects to illustrate applications, a limitation is that it did not include original empirical fieldwork (such as post-occupancy evaluations or user experiments in designed spaces). Incorporating such empirical validations would strengthen the evidence base and could be a fruitful direction for further study. Despite these limitations, the intention has been to provide an accessible synthesis of current knowledge, serving as a springboard for designers and researchers who wish to apply these insights or delve deeper into the neuroarchitecture field

There will always be an art to using this science: knowing when a guideline should be followed, when it should be bent, or when an outlier case calls for an entirely bespoke solution. Truly human-centred design in this context means designing with people rather than just for people. This involves engaging users (through methods like the neurobriefing or participatory design sessions), respecting diversity in human experience, and approaching each project with humility about what we do not know. If there is one overarching lesson from this research, it is that interior design for well-being thrives on an integrative mindset, one that welcomes insights from neuroscience, psychology and beyond, yet filters them through a compassionate understanding of human individuality. With this perspective, designers can better ensure that the environments they create are not just aesthetically pleasing or functionally adequate, but genuinely supportive of the minds and bodies that inhabit them.

CONCLUSION

The discussions throughout this dissertation point to a single overarching idea: designing interiors that promote well-being demands an integrative approach, one that pairs scientific findings with an empathetic understanding of human experience. Each strategy presented here, calming colour palettes, circadian-tuned lighting, comforting materials, supportive spatial scale, biophilic elements, and carefully balanced sensory cues, adds a complementary layer to the broader aim of creating healthier, more supportive spaces.

Crucially, implementing these strategies does not imply a one-size-fits-all formula. The designer selects and adapts them to suit each project's context and occupants. A human-centred design ethos means continually asking: *Who will use this space, and how do we want them to feel and function while here?* The strategies then serve as a toolbox. For a given project, some tools will be more salient than others. A care home for the elderly might prioritise circadian lighting and calming colours to mitigate anxiety, along with strong biophilic cues to reduce stress, whereas a design for a tech office's innovation hub might emphasise moderate visual stimulants (sparks of colour, dynamic lighting) and flexible scaling of spaces to inspire creativity. In all cases, iterative user-centric testing (potentially using new methods like VR simulations with biometric feedback, can help fine-tune these design elements to the target population.

The strategies outlined are supported by recent evidence, but their successful integration relies on design judgement. The artful balancing of factors to avoid over-stimulation or monotony. For instance, too much biophilia without maintenance can lead to indoor allergens or a "jungle" that not all users appreciate; likewise, excessive emphasis on any single sense might inadvertently create discomfort (as seen when well-lit spaces forget acoustics, or vice versa). Therefore, the designer acts as a synthesiser, ensuring coherence and harmony among colour, light, texture, scale, and natural elements so that the end result feels organic and effortless to the user.

These neuroscience-informed strategies also resonate with phenomenological design principles discussed earlier in the dissertation. Both perspectives insist on attending to the qualitative, lived experience of space. Neuroscience gives designers data, for example, which lighting schedules measurably improve sleep, or how wood versus plastic affects heart rate, while phenomenology reminds that individuals ultimately experience these spaces through personal perception and cultural lenses. Together, they guide us toward interiors that are not only *efficient and evidence-based* but also *meaningful and empathetic*. This synergy represents a key contribution of the dissertation: demonstrating that scientific research can enrich, rather than diminish, the designer's poetic intuition about space, material, and atmosphere. In practice, a human-centred, neuroscience-applied design might be seen as a new paradigm of *"evidence-based empathy"* – using research to better care for users' unseen needs (like reducing cognitive load or stress hormones) even as we craft spaces that speak to their senses and spirit.

The importance and applicability of these findings lie in their potential to elevate interior design from a primarily aesthetic or functional pursuit to a more holistically human-centred practice. By reaffirming that design decisions can have measurable impacts on occupants' nervous systems, stress levels, mood and even cognitive clarity, this dissertation underscores the ethical and practical responsibility of designers to consider well-being as a fundamental goal. The guidelines and principles outlined, can be directly applied across a variety of environments. From healthcare facilities and schools to workplaces, retail and homes, the research-backed strategies discussed here provide a toolkit for creating interiors that actively support mental and physical health. Moreover, these insights foster a more integrative design process. They also promote an interdisciplinary process: architects and interior designers collaborating with neuroscientists, psychologists and end-users; employing tools such as biometric feedback and immersive simulations; and viewing buildings as finely tuned habitats rather than mere enclosures. This approach aligns with the broader movement towards evidence-based design in the built environment, reinforcing the idea that well-designed spaces are a crucial component of public health and quality of life.

While this work has consolidated current knowledge and offered clear guidelines, it also highlights that the integration of neuroscience into interior design is an ongoing journey rather than a finished product. New research will undoubtedly emerge, whether it's breakthroughs in understanding how the brain responds to environmental stimuli or improved methods of measuring human experience in spaces (such as neuroimaging and biometric feedback becoming more accessible for design research). Designers should view the recommendations made here as *living principles*, ones that must be continually tested, questioned, and updated as scientific understanding deepens. In professional practice, this translates to a mindset of critical engagement and adaptability. Rather than uncritically applying "neuro design" rules, effective practitioners will remain curious and discerning, consulting up-to-date research, gauging the success of their interventions through user feedback or empirical data, and being willing to adjust course when evidence suggests a better approach. This adaptive mindset ensures that design remains responsive to both the latest knowledge and the unique context of each project.

Going forward, the hope is that more designers will embrace this evidence-informed yet humanistic mindset. By doing so, the discipline of interior design can continue to evolve, not only keeping pace with new scientific insights, but also shaping them through innovative practice, all in service of creating environments where individuals and communities can truly thrive.

REFERENCES

Afifi, M. B., Krumrei-Mancuso, E. J., & Trammell, J. (2023). Effects of color and lighting temperature on mood and cognitive performance. Psi Chi Journal of Psychological Research, 29(3), 169–180. https://doi.org/10.24839/2325-7342.JN29.3.169

Alexander, C., Ishikawa, S., & Silverstein, M. (1977). A pattern language: Towns, buildings, construction. Oxford University Press.

ANFA | *History*. (n.d.). https://anfarch.org/about/history

Aries, M. B., Aarts, M. P., & van Hoof, J. (2015). Daylight and health: A review of the evidence and consequences for the built environment. *Lighting Research & Technology*, *47*(1), 6-27.

ANFA | *Mission*. (n.d.). https://anfarch.org/about/mission

ArchDaily. (2019, November 16). Two Union Square Lobby / NBBJ. https://www.archdaily.com/928554/two-union-square-lobby-nbbj

ArchDaily. (2021, January 20). The University of Virginia, University Hospital Expansion / Perkins&Will. https://www.archdaily.com/956074/the-university-of-virginia-university-hospital-expansion-perkins-and-will

Assem, H. M., Khodeir, L. M., & Fathy, F. (2023). Designing for human wellbeing: The integration of neuroarchitecture in design – A systematic review. Ain Shams Engineering Journal, 14(6), 102102. https://doi.org/10.1016/j.asej.2022.102102

Bachelard, G. (2014). The poetics of space. Penguin Classics.

Barata, A. M. (2008). Arquitectura e design: contributos de William Morris e Walter Gropius. Via Panorâmica: Revista de Estudos Anglo-Americanos/A Journal of Anglo-American Studies, (1), 40–58.

Bear, M. F. (2020). Neuroscience: Exploring the brain (4th ed.). Wolters Kluwer.

Bear, M. F., Connors, B. W., & Paradiso, M. A. (2017). Neurociências: Desvendando o sistema nervoso. Artmed Editora.

Bestetti, M. L. T. (2014). Ambiência: espaço físico e comportamento. Revista Brasileira de Geriatria e Gerontologia, 17(3), 601–610. https://doi.org/10.1590/1809-9823.2014.13083

Bower, I. S., Hill, A. T., & Enticott, P. G. (2023). Functional brain connectivity during exposure to the scale and color of interior built environments. Human Brain Mapping, 44(2), 447–457. https://doi.org/10.1002/hbm.26061

Bower, K., Tucker, R., & Shrimpton-Smith, L. (2022). The influence of room colour on emotional and neural responses: An EEG study in virtual reality. Journal of Environmental Psychology, 81, 101803. https://doi.org/10.1016/j.jenvp.2022.101803

Breitenfeld, T., Jurasic, M. J., & Breitenfeld, D. (2014). Hippocrates: The forefather of neurology. Neurological Sciences, 35(9), 1349–1352.

Clemenson, G. D., Deng, W., & Gage, F. H. (2015). Environmental enrichment and neurogenesis: From mice to humans. Current Opinion in Behavioral Sciences, 4, 56–62. https://doi.org/10.1016/j.cobeha.2015.02.005

Constitution of the World Health Organization, signed on July 22, 1946, in New York City. (1947). International Organization, 1(1), 225–239. https://doi.org/10.1017/S0020818300007049

Damásio, A. (1996). O erro de Descartes: Emoção, razão e o cérebro humano. Companhia das Letras.

Daudt, F. (2018). Design para forças de caráter: Estudo sobre a aplicação da abordagem de design voltada ao bem-estar subjetivo [Master's dissertation, Universidade do Vale do Rio dos Sinos]. Repositório Jesuíta. http://www.repositorio.jesuita.org.br/handle/UNISINOS/7414

De Botton, A. (2008). The architecture of happiness. Vintage.

De Paiva, A. (2018). Neuroscience for architecture: How building design can influence behaviors and performance. Journal of Civil Engineering and Architecture, 12(2), 132–138.

Djebbara, Z., Fich, L. B., Petrini, L., & Gramann, K. (2019). Sensorimotor brain dynamics reflect architectural affordances. *Proceedings of the National Academy of Sciences*, *116*(29), 14769-14778.

Eberhard, J. P. (2009). Applying neuroscience to architecture. Neuron, 62(6), 753–756.

Ellard, C. (2015). Places of the heart: The psychogeography of everyday life. Bellevue Literary Press.

Elsayed, M., Elshater, A., Shehayeb, D., Finka, M., & Afifi, S. M. (2024). Exploring the restorative environments in Bratislava using EEG and VR: a neuro-urbanism approach. Archnet-IJAR: International Journal of Architectural Research.

Figueiro, M. G., & Rea, M. S. (2016). Office lighting and personal light exposures in two seasons: Impact on sleep and mood. *Lighting Research & Technology, 48*(3), 352–364.

Fred H. Gage. (2023). In Encyclopedia Britannica. https://www.britannica.com/biography/Fred-H-Gage

Frédéric, S. E. M. (2009). Healing spaces: The science of place and well-being. Harvard University Press.

Gage, F. H. (2002). Neurogenesis in the adult brain. Journal of Neuroscience, 22(3), 612–613.

Garcia, A. (2021). Fenomenologia e experiências sensoriais em interiores. Revista Intramuros. https://revistaintramuros.com.br/fenomenologia-e-experiencias-sensoriais-em-interiores/

Gardner, E., & Johnson, K. O. (2013). The somatosensory system. Handbook of Clinical Neurology, 115, 25–44.

Gensler. (n.d.). Pinterest Mexico City. https://www.gensler.com/projects/pinterest-mexico-city

Gifford, R. (2014). Environmental psychology: Principles and practice (5th ed.). Optimal Books.

Gonçalves, R., & Paiva, A. D. (2018). Triuno – Neurobusiness e qualidade de vida. Edição do Autor.

Hagerhall, C. M., Laike, T., Taylor, R. P., Küller, M., Küller, R., & Martin, T. P. (2008). Investigations of human EEG response to viewing fractal patterns. *Perception*, *37*(10), 1488–1494. https://doi.org/10.1068/p5918

Heschong, L., Wright, R. L., & Okura, S. (2002). Daylighting impacts on human performance in school. *Journal of the Illuminating Engineering Society*, *31*(2), 101-114.

Joye, Y., & van den Berg, A. E. (2011). *Is love for green in our genes? A critical analysis of evolutionary assumptions in restorative environments research*. Urban Forestry & Urban Greening, 10(4), 241–248. https://doi.org/10.1016/j.ufug.2011.05.002

Joye, Y., Willems, K., Brengman, M., & Wolf, K. (2010). The effects of urban retail greenery on consumer experience: Reviewing the evidence from a restorative perspective. Urban Forestry & Urban Greening, 9(1), 57-64.

Kanashiro, M. (2003). A cidade e os sentidos: Sentir a cidade. Desenvolvimento e Meio Ambiente, 7, 1–14. https://doi.org/10.5380/dma.v7i0.3051

Kaplan, R., & Kaplan, S. (1989). The experience of nature: A psychological perspective. Cambridge University Press.

Küller, R., Mikellides, B., & Janssens, J. (2009). Color, arousal, and performance—A comparison of three experiments. Color Research & Application, 34(2), 141–152.

LaBar, K. S., & Cabeza, R. (2006). Cognitive neuroscience of emotional memory. Nature Reviews Neuroscience, 7(1), 54–64. https://doi.org/10.1038/nrn1825

Lee, K. E., Williams, K. J. H., Sargent, L. D., Williams, N. S. G., & Johnson, K. A. (2015). *40-second green-roof views sustain attention: The role of micro-breaks in attention restoration*. Journal of Environmental Psychology, 42, 182-189. https://doi.org/10.1016/j.jenvp.2015.04.003

Li, D., & Sullivan, W. C. (2016). Impact of views to school landscapes on recovery from stress and mental fatigue. Landscape and urban planning, 148, 149-158.

Matoso, M. (2022, May 31). Neuroarquitetura: Como o seu cérebro responde aos espaços. ArchDaily Brasil. https://www.archdaily.com.br/br/981830/neuroarquitetura-como-o-seu-cerebro-responde-aos-espacos

Meadows, D. (2008). Thinking in systems: A primer. Chelsea Green.

Mehta, R., & Zhu, R. (2009). Blue or red? Exploring the effect of colour on cognitive task performances. Science, 323(5918), 1226–1229.

Meyers-Levy, J., & Zhu, R. (2007). The influence of ceiling height: The effect of priming on the type of processing that people use. *Journal of consumer research*, *34*(2), 174-186.

Mitchell, N. (2010, October 16). Esther Sternberg: The science of stress, place and wellbeing [Audio podcast episode]. In All in the Mind. ABC Radio National.

Norberg-Schulz, C. (1980). Genius loci: Towards a phenomenology of architecture. Rizzoli.

Norman, D. A. (2004). Emotional design: Why we love (or hate) everyday things. Basic Books.

Norman, D. A. (2023). Design for a better world. MIT Press.

Özçam, I. (2022). Experiencing the space with a phenomenological approach: A method proposal for relating the senses with representation and design. IDA: International Design and Art Journal, 4(1), 12–25.

Pallasmaa, J. (1994). An architecture of the seven senses. Architecture and Urbanism, 7, 27–38.

Pallasmaa, J. (2012). The eyes of the skin: Architecture and the senses (3rd ed.). John Wiley & Sons.

Pallasmaa, J., Mallgrave, H. F., Robinson, S., & Gallese, V. (2015). Architecture and empathy. Tapio Wirkkala Rut Bryk Foundation.

Pintos, P. (2024, July 25). Two Union Square Lobby / NBBJ. ArchDaily. https://www.archdaily.com/928554/two-union-square-lobby-nbbj

Rangel, V. L., & De Souza Matos, L. B. (2021). Neuroarquitetura e psicologia das cores: sensações e psicodinâmica no design de interiores. Revista Geometria Gráfica, 5(2), 66. https://doi.org/10.51359/2595-0797.2021.252739

Rapoport, A. (1990). The meaning of the built environment: A nonverbal communication approach. University of Arizona Press.

Rogers, K. (2025, January 1). *Fred H. Gage*. *Encyclopedia Britannica*. https://www.britannica.com/biography/Fred-H-Gage

Rosendahl, Z., & Corrêa, R. L. (Eds.). (2013). *Geografia cultural: uma antologia, Vol. 2* (Vol. 2). SciELO-EDUERJ.

Ruiz-Arellano, M. (2015). Hawaiian healing center: A weaving of neuro-architecture and cultural practices [Master's thesis, University of Hawai'i at Mānoa]. ScholarSpace. http://scholarspace.manoa.hawaii.edu/handle/10125/50858

Salk Institute for Biological Studies. (2024, August 14). History of Salk. https://www.salk.edu/about/history-of-salk/

Sanders, E. B.-N., & Stappers, P. J. (2008). Co-creation and the new landscapes of design. CoDesign, 4(1), 5–18.

Santos, V. C. M. D. (2023). Neuroarchitecture: How the built environment influences the human brain. Revista Científica Multidisciplinar Núcleo do Conhecimento, 96–113. https://doi.org/10.32749/nucleodoconhecimento.com.br/architecture/neuroarchitecture

Smolders, K. C., & de Kort, Y. A. (2014). Bright light and mental fatigue: Effects on alertness, vitality, performance and physiological arousal. *Journal of environmental psychology*, *39*, 77-91.

Spence, C. (2020). Senses of place: Architectural design for the multisensory mind. Cognitive Research: Principles and Implications, 5, 46. https://doi.org/10.1186/s41235-020-00243-4

Sternberg, E. M. (2009). Healing spaces: The science of place and well-being. Harvard University Press.

Shanahan, D. F., Astell-Burt, T., Barber, E. A., Brymer, E., Cox, D. T. C., Dean, J., Depledge, M., Fuller, R. A., Hartig, T., Irvine, K. N., Jones, A., Kikillus, H., Lovell, R., Mitchell, R., Niemelä, J., Nieuwenhuijsen, M., Pretty, J., Townsend, M., van Heezik, Y., Warber, S., … Gaston, K. J. (2019). Nature-Based Interventions for Improving Health and Wellbeing: The Purpose, the People and the Outcomes. *Sports (Basel, Switzerland)*, *7*(6), 141. https://doi.org/10.3390/sports7060141

Sztuka, I. M., Becker, M., & Kühn, S. (2025). Neural representations underlying psychological responses to natural and artificial features in indoor architecture. *Journal of Environmental Psychology*, *103*, 102553.

Taylor, R. P., Spehar, B., Wise, J. A., Clifford, C. W., Newell, B. R., Hagerhall, C. M., Purcell, T., & Martin, T. P. (2005). Perceptual and physiological responses to the visual complexity of fractal patterns. *Nonlinear dynamics, psychology, and life sciences*, *9*(1), 89–114.

Ulrich, R. S. (1984). View through a window may influence recovery from surgery. *science*, *224*(4647), 420-421.

Ulrich, R. S., Simons, R. F., Losito, B. D., Fiorito, E., Miles, M. A., & Zelson, M. (1991). Stress recovery during exposure to natural and urban environments. Journal of Environmental Psychology, 11(3), 201–230.

Vartanian, O., Navarrete, G., Chatterjee, A., Fich, L. B., Leder, H., Modroño, C., ... & Skov, M. (2013). Impact of contour on aesthetic judgments and approach-avoidance decisions in architecture. *Proceedings of the National Academy of Sciences*, *110*(supplement_2), 10446-10453.

Vartanian, O., Navarrete, G., Chatterjee, A., Fich, L. B., Leder, H., Modroño, C., Nadal, M., Rostrup, N., & Skov, M. (2015). *Architectural design and the brain: Effects of ceiling height and perceived enclosure on beauty judgments and approach-avoidance decisions*. Journal of Environmental Psychology, 41, 10–18. https://doi.org/10.1016/j.jenvp.2014.11.006

Villarouco, V., Ferrer, N., Paiva, M. M., Fonseca, J., & Guedes, A. P. (2021). Neuroarquitetura: A neurociência no ambiente construído. Rio Books.

Zeisel, J. (2006). Inquiry by design (2nd ed.). W. W. Norton.

Zeisel, J. (2013). Improving person-centered care through effective design. Generations, 37(3), 45–52.

Zhang, X., Lian, Z., & Wu, Y. (2017). Human physiological responses to wooden indoor environment. Physiology & Behavior, 174, 27–34. https://doi.org/10.1016/j.physbeh.2017.02.043