

# **A Review on Spatial Perception Through Neuro-Architecture**

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Submitted to the  
Institute of Graduate Studies and Research  
in partial fulfillment of the requirements for the degree of

Master of Science  
in  
Architecture

Eastern Mediterranean University  
August 2023  
Gazimağusa, North Cyprus

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## **ABSTRACT**

Nowadays, people spend most of their time indoors and are affected both psychologically and physiologically by the places they are in. As the place affects people, it can also control their feelings in some cases.

In recent years, neuroscience and psychology professionals have begun to combine their research to provide more robust data on human mental health and perception under the title of neuro-architecture. While the conditions that affect human psychology can now be defined by physical, chemical, and biological phenomena occurring in the brain, it is also becoming a little clearer how phenomena occurring in the brain affect human perception. Within the scope of the thesis, as a result of the findings of neuroscience and psychology researchers in recent years, it has been examined how these data can affect the neuro-architecture and architectural design process. It investigated how the human brain, which perceives its environment through five senses, is affected by visual, auditory, sensory, olfactory, and tactile phenomena in spaces and how it changes its perception and psychology.

**Keywords:** Psychology, Neuroscience, Architectural Design, Human Brain and Perception, Spatial Perception, Architectural Psychology, Sense Organs and Perception

## ÖZ

Günümüzde insanlar hayatlarının büyük bir kısmını kapalı mekanlarda geçirmekte, ve içinde buldukları mekanlardan hem psikolojik hem de fizyolojik olarak etkilenmektedir. Mekan, insanları etkilediği gibi bazı durumlarda davranışlarını da kontrol edebilmektedir.

Son yıllarda sinir bilim ve psikoloji profesyonelleri, araştırmalarını birleştirerek insanların mental sağlıkları ve davranışları ile ilgili daha güçlü veriler elde etmeye başladı. Artık insan psikolojisini ve davranışlarını etkileyen durumlar beyinde meydana gelen fiziksel, kimyasal ve biyolojik olgular ile tanımlanabiliyorken, aynı şekilde beyinde meydana gelen olguların da insan psikolojisini ve davranışlarını nasıl etkilediği biraz daha net bir şekilde anlaşılakta. Bu tez kapsamında, sinir bilim ve psikoloji araştırmacılarının son yıllarda ulaştıkları bulgular sonucunda, bu verilerin mimari tasarım sürecine nasıl etki edebileceği incelendi. Çevresini beş duyu organı aracılığıyla algılayan insan beyninin, mekanlardaki görsel, işitsel, duyuusal, kokusal ve dokunsal olgulardan nasıl etkilendiği ve bu duylara bağlı olarak hareketlerini ve davranışlarını nasıl değiştirdiği araştırıldı. Mimari proje kapsamında incelenen Marmaris 125 Yataklı Devlet Hastanesi projesi, araştırmalar ışığında yorumlandı. Sonuç olarak, yapılan hastanenin, kullanıcı memnuniyetine uygun olduğu görüldü.

**Anahtar Kelimeler:** Psikoloji, Sinirbilim, Mimari Tasarım, İnsan Beyni ve Algısı, Mekansal Algı, Mimari Psikoloji, Duyu Organları ve Algı

*To my beloved family.*

## **ACKNOWLEDGMENT**

I would like to record my gratitude to my esteemed professors at the Eastern Mediterranean University, Faculty of Architecture, who supported me throughout my undergraduate and graduate education and encouraged me to walk on the academic path and all my friends with whom I walked on this path and who did not spare me their moral support.

And the most needed, to my dear advisor Prof. Dr. S. Müjdem Vural whom I am proud to be her student, and whose knowledge and experience did not detract from me during the development period of my thesis.

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# Chapter 1

## INTRODUCTION

Some of the social science research lines up that, while people are shaping the places that they are living in with their emotional and behavioral orientations, they also change psychologically and physiologically through the built environment. Even, in 1943, Sir Winston Churchill said “we shape our buildings; thereafter they shape us.” [1]. This quote reveals the effect of the built environment on human feelings, emotions, and perceptions. This means, that every element of the built environment has its own unique nature, which impacts human emotions, feelings, and perception. At this point, it should be said that each building should generate its own specific characteristics and its own unique feeling for the user which helps the user to understand and perceive the space comprehensively. Recently this topic is studied under the title of architectural psychology. Even, neuro-scientists find a new research area that will emphasize the importance of the relation between perception and psychology of space with the development process of architectural applications and they call it Neuro-Architecture. Neuro-Architecture basically, investigates the relations between the human brain, perception of space through the human brain, and the brain’s reaction to them with emotions.

### 1.1 Problem Statement

People spend most of their time indoors nowadays. Their jobs, homes, areas where they socialize, areas where they do sports, and areas where they eat are always indoors. The places they are in greatly affect the emotions, feelings, and perceptions of them.

Exactly on this subject, in recent studies, the importance of some places, especially the places where people are working, to the psychology of people has begun to be investigated. As a result of these research, analyses, and experiments, the effect of people's being in closed places on the hormones secreted in their brains was noticed. While architectural structures have such an important place in human emotions, feelings, and perceptions, it has become a popular research area today to strengthen and dominate this importance by supporting it with other branches of science. At this point, in the architectural design process, it was discovered that neuroscience and psychology are the most important disciplines in order to examine human psychology.

As a result of all this research, in this thesis, by trying to find a solution to the problem of people feeling uncomfortable, and unmotivated in spaces, by discovering the factors affecting the five sense organs in spatial designs, solutions were sought for problems such as their positive or negative effects on human psychology.

## **1.2 Aim of Thesis**

The aim of this thesis is to examine and evaluate the findings related to human perception in the direction of neuroscience and psychology disciplines from an architectural point of view. In recent years, neuroscience and psychology disciplines have done a lot of research on how human psychology and perception are affected. As a result of these studies, it has been concluded that people can be affected by the places they live in. In this thesis, the studies of three disciplines -neuroscience, psychology, and architecture- will be brought together and investigated under the title of Neuro-Architecture, how the data in the spaces turn into perception in the brain will be examined.

In addition, this thesis aims to examine the perceptions of psychology and neuroscience on people in such places by explaining several case studies that directly affects human health, together with existing cases.

### **1.3 Limitation**

The research examined within the scope of this thesis and the literature reviews present interdisciplinary research in psychology, neuro-science and architecture, and aim to investigate only the areas that architecture can affect in the human brain. Since the human brain has a comprehensive structure and complex findings, this is stated in the thesis, and within the scope of the research, the process of perceptions obtained from the five sense organs in the brain and their effects on human psychology are investigated. In line with all these, how the five sense organs affect psychology and behavior has been architecturally examined. It is limited to examining what kind of effects the designs created with architectural touches in these closed spaces cause on people's psychology after being perceived the built environment through the five senses. With the understanding of all these processes, discussions and ideas on case studies are presented.

### **1.4 Methodology**

This study has potential limitations and they are based on literature reviews and data collections. Theoretical, methodological, analytical, and empirical research represent the reliability, diversity, and validity of the findings.

Since the phenomena in the spaces are transmitted to the brain through five sense organs, the working mechanism of the five sense organs will be evaluated using the findings of the neuroscience discipline. What processes the data transmitted to the brain goes through in the brain and the feelings it creates in people will be explained

with the help of the discipline of psychology. While researching the parts up to this chapter, literature reviews and documentary research will be done. At the same time, in order to support all these data, data collection was made about the experiments carried out by scientists who were experts in their fields. Then, the related case studies were examined by observation and the findings were evaluated.

## **1.5 Structure of Thesis**

This thesis consists of five main chapters. The first chapter is called the introduction, and information about the aim, limitation and methodology of the thesis is given in this part. In the second chapter, the relationship between the human brain, psychology, and neuroscience, their literature reviews, and data documentation were examined in detail. The third chapter in conjunction with the second chapter, presents research on how previously obtained information affects the perception process in the brain and the impact of perception on psychology. In the fourth chapter, how these perceptions that may occur in places affect psychology was investigated. While this process was examined within the framework of neuro-architectural discipline, case studies were examined in detail. As a result of the thesis, in the fifth chapter, inferences, results, and findings are revealed.

## **Chapter 2**

# **HUMAN BRAIN, PSYCHOLOGY, AND NEUROSCIENCE**

Humans are highly developed animals, not only with their bodies and biological features but with their intellectual capacities as well. Humans are more challenging to understand than other animals when considering their behaviors, feelings, and emotions. Mainly those differences are caused by their unique brain structures. According to the Cambridge Dictionary, the basic brain is defined as “The organ inside the head that controls thoughts, memory, feelings, and activity”. On the other hand, according to the Oxford Languages Dictionary, in the most fundamental way, the human brain is defined as “...intellectual capacity”. On a general scale, even the definitions of the basic human brain in dictionaries differ. Establishing cause-effect relationships, producing solutions, and learning new skills are crucial aspects of human intelligence, and these are the main features that distinguish the brain of a human from the brains of other animals. Therefore, this intellectual capacity has a critical role in the psychological mood of humans and changes their perceptions and experiences of different phenomena.

From this point of view, the nervous system is one of the systems that greatly impacts human psychology because any emotion formed in the brain can be accessed through the central nervous system in human anatomy. Apart from these, the brain’s enzymes, hormones, and other connective secretions directly affect human psychology. People

whose psychology is affected in different ways create emotions that can vary from person to person and also from situation to situation. For this reason, to understand human emotions and feelings, it is necessary to understand the brain and the working process of the brain. To understand the mental work of the brain, it is necessary to decipher the physical work of the brain.

Neuroscience is the primary science that studies the brain and its anatomy, chemistry, and biology; on the other hand, psychology is also a science that does much research on the human brain. However, neuroscience and psychology focus on different domains. While neuroscience focuses more on the physical, biological, and chemical functions and changes of the brain, psychology deals with the more abstract dimension of the brain and tries to understand the mental effects of changes in the brain on people [2]. Neuroscience contributes greatly to psychiatrists and psychologists by conducting brain research to understand people's psychological problems better. For example, neuroscience research has shown that schizophrenia is associated with abnormalities in the structure and function of the brain, Alzheimer's also demonstrates this fact. This knowledge has led to new treatments for these conditions [3]. This is a case that cannot be solved without the help of neuroscience to psychology. Furthermore, recently, this linkage between psychology and neuroscience has become clear and concrete. Last but not least, this connection has inspired not only these two disciplines, but also all other disciplines of research that study human behavior, emotions, and feelings.

## **2.1 Introduction to Complexity of the Human Brain**

Humans are weak and incompatible with their surroundings, and simultaneously, it is the biggest difference that separates them from the other animals. All animals in nature have particular organs or abilities that help them survive in the wild. For instance, a

cheetah's fast running, a bee's sting, a sunk scent, a bird's wings, and flight abilities have led these animals to act with defense or attack instinct. Humans do not have such a talent, and from the outside, it seems like human beings cannot survive in nature, but today they are the strongest animals in the world. Because people have the chance to develop and update themselves emotionally and physically by using their brains for cognitive activities; unlike other animals, they have different skills like language, tool making, reasoning, empathy, and social consciousness. This contradictory situation was exactly what prompted researchers to investigate the main reason that separates the human brain from other animals' brains.

As it is known, humans are biologically classified as animals as well. However, unlike other animal brains, the human brain has conscious abilities, which is possible with a few specific features found in the human brain. One of the best studies on this subject is done by Todd M. Preuss. According to him, there is more than one reason why the human brain works differently.

For starters, our brains weigh an average of three pounds, which is enormous for an animal of our body size. By comparison, chimpanzees, our closest living relatives, have brains that are one-third the size of our own, although they are very similar to us in body size. In addition to having more neurons in the association cortex, brain imaging studies comparing the brains of humans to other primates show humans have a greater number of fibers connecting the brain regions involved in such human-specialized functions as language, tool-making, reasoning, and social cognition... As humans evolved, studies show that changes occurred in the patterns of gene expression in the brain, impacting everything from brain metabolism to the ability of cells to establish new connections with other cells [4].

Although these findings have been reached as a result of some experiments and research, there is still uncertain information about the complex structure of the human brain. Hereof, Sir Charles Scott Sherrington says, "The brain is a mystery; it has been and still will be..." [5].

As a matter of fact, there are lots of saying about the human brain by the connoisseurs of different professions. One of the best words from Owen Jay Gingerich himself that describes the complexity of the human brain is quoted. He said ‘‘The human brain is by far the most complex physical object known to us in the entire cosmos’’. It is known today that the cosmos is one of the most complex structures of our time. With this quote, it is clear that competent people see the brain’s complex structure, as even more confusing than the cosmos structure. On the other hand, some researchers from the same academic field say that the structure of the cosmos and the structure of the brain are very similar to each other, and in their literal terms, ‘‘...human brain is similar to the cosmos. Both neural and galactic connections have similar structures and form a fractal-shaped pattern.’’ (Figure 1) [6].

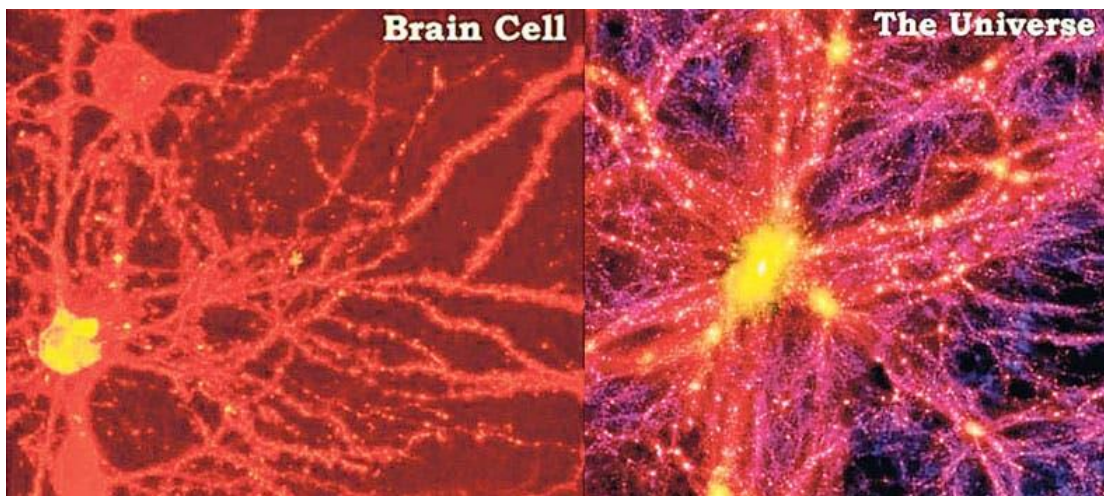


Figure 1: Similarity of human brain cell connections and galaxy cosmic web connections [6]

In other words, the Galaxy is similar to the human brain or vice versa, there are tiny galaxies in every person’s brain. Also, to highlight this incredible connection and relationship between the brain and the universe, ‘‘As long as our brain remains a mystery, the cosmos, the reflection of the structure of the brain, will also be a mystery’’ Santiago Ramon Cajal once said [7]. In summary, all these studies and discourses from

different branches of research show once again the complex structures of the brain and its mystery.

## **2.2 Nervous System**

All the features mentioned above are related to the human brain. Nevertheless, of course, the human brain is not an independent organ. There is a system in which the brain is included, and in this system, it is an organ that works together with different structures [8].

Simply put, the brain is responsible for perceiving the events in the outside world and sending them to the relevant centers in the human body. For this system to work regularly, of course, a centrally located system is needed between the brain and the human body. The name of the system that performs precisely this function from the human body is called the nervous system. The nervous system includes fundamental building blocks, and these are called neurons; these neurons can be briefly described as message transmitters that send pieces of information from one point to another. Neurons convey information using chemical and physical impulses, and these signals allow the brain, spinal cord, and other body parts to communicate with one another [9]. Only the functioning of neurons and their support cells would make it possible for individuals to think, feel, and act the way they do. Three key components make up a neuron; the cell body is one of them, and the other two can be compared to two separate branches that emerge from it. The axon and dendrite are the names of these two branches (Figure 2). The axon, which resembles a tail, is a structure that transmits or conveys messages. The structure that receives messages from the cell is called a dendrite, which has a dispersed appearance resembling a tree branch. Neurons interact by passing chemicals known as transmitters over minuscule gaps between their axons

and dendrites, a process known as synapses. These neurons send the data they receive to the necessary cortexes; after processing them in the brain and spinal cord, the signals reach the relevant areas in the body and finally cause the person to react or reflex. Although neurons are tiny particles, they are fundamental particles of the nervous system. A group of neurons forms a nerve. Furthermore, these nerves can even be called the primary structural blocks of the nervous system. Therefore, they are crucial for the coordinated functioning of the nervous system.

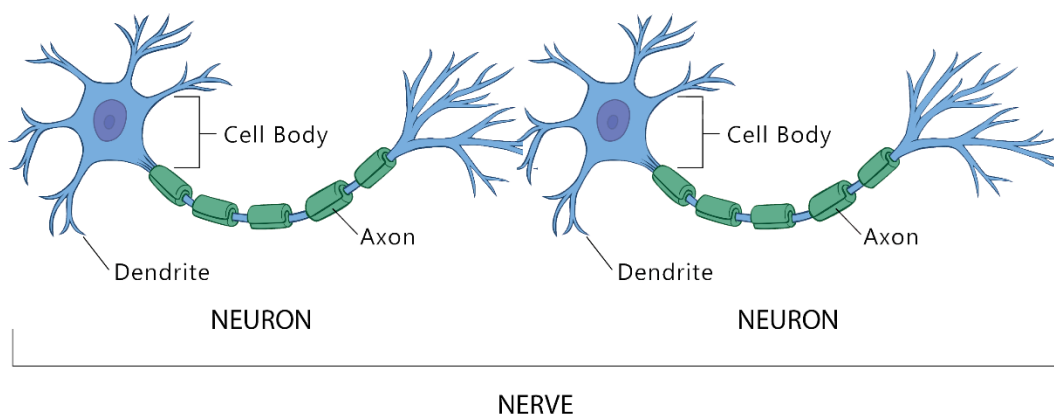
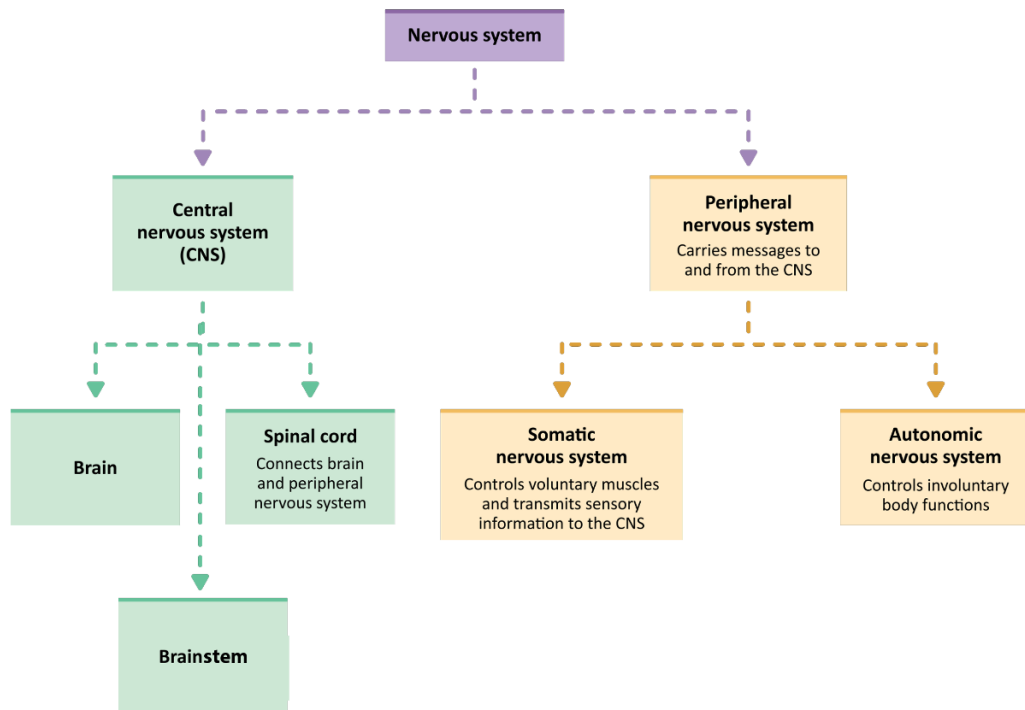


Figure 2: A nerve, consisting of two neuron structures that contain a cell body, dendrite, and axon [9]

On a larger scale, the nervous system consists of two different systems called; the peripheral nervous system and the central nervous system (Figure 3) (Table 1). The peripheral nervous system is a system that includes nerves that connect the brain and spinal cord to the rest of the body. Basically, the peripheral nervous system is in charge of sending or receiving messages from the central nervous system. The somatic nervous system and the autonomic nervous system are two separate systems that are inside of the peripheral nervous system. The somatic nervous system regulates voluntary muscles and sends sensory data to the central nervous system. The autonomic nervous system regulates autonomic bodily processes like breathing,

heartbeat, blinking, and others. The central nervous system, on the other hand, is basically made up of the brain and the spinal cord. Numerous physical processes, including, awareness, behavior, judgment, language, and the five senses of sight, hearing, taste, smell, and touch, are controlled by the brain. The network of nerves that are attached to the spinal cord acts as an extension of the brain, carrying signals to and from it. Additionally, the brainstem, a region of the brain was connected to the spinal cord by nerves [10].

Table 1: Nervous System Types [9]



The brain occupies the largest portion of the two parts that make up the central nervous system. However, of course, the fact that the brain is large in portion does not make it more or less important than the spinal cord. Both are easily described as main structures. Neurons, which are cells that store, process, and sense information using electrical and chemical impulses, are also a component of them [11].

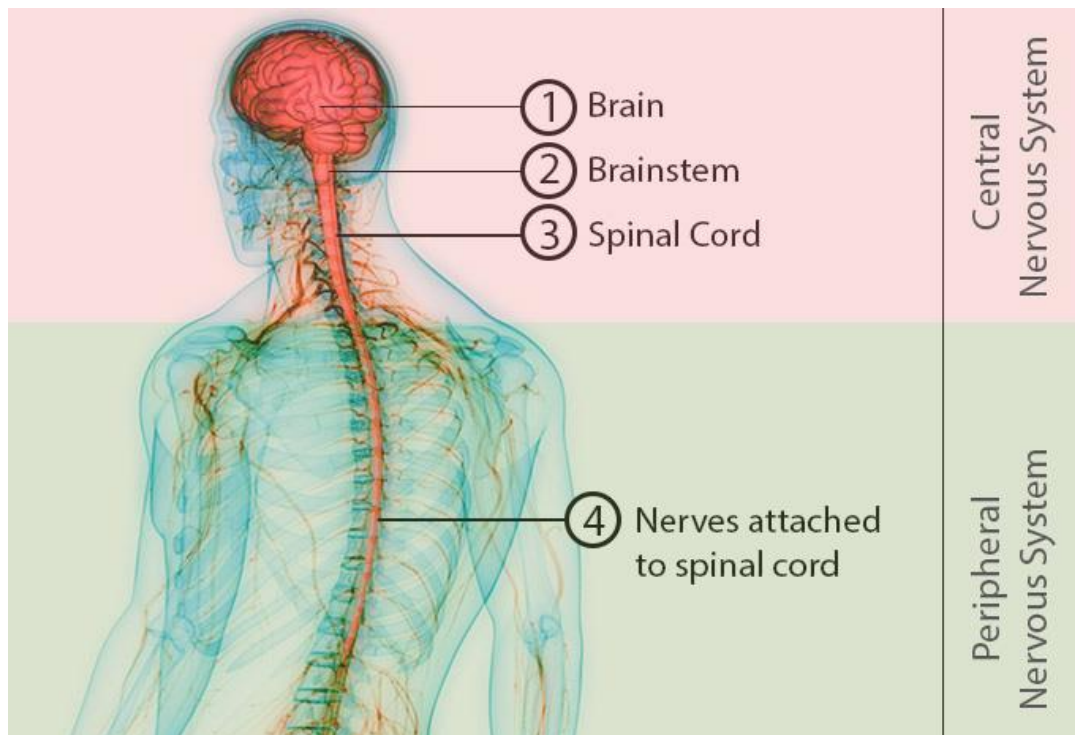


Figure 3: Nervous System [9]

A transparent fluid called cerebrospinal fluid and three layers of membranes called meninges shield to protect the brain and spinal cord from any kind of harm [12]. Apart from these, the most important thing in the protection process of the nervous system as a whole is the intricate layers that are the skull and the backbone. The especially human head contains the concentration of sensory organs in the body, including the eyes, tongue, and olfactory systems. This means that all the functional features in the body that need to be preserved are located in the brain and the central nervous system, inside the skull, and in the backbone. For this reason, the skull and the backbone play a critical role in protecting vital functions [13].

It is very important that these structures protect the brain and indirectly the nervous system. Otherwise, this system, which has a susceptible structure, will cause changes in human psychology and physiology in line with the damages it receives from any

part of the system. Moreover, at the end of the day, these changes lead to deterioration in human emotions, feelings, and perceptions. Due to this reason, it is of great importance to examine the structure in the brain's outer shell and its importance in affecting psychology.

### **2.3 Anatomy of the Human Brain**

There are different parts of the nervous system with different functions, but most have a specific and well-defined function. Here, the real mystery and confusion is in the brain. Researchers have studied the human brain for a very long time and certain points cannot be obtained yet. What makes the brain so interesting is that it is formed in the lobes within the abstract concepts called human emotions and feelings. It is tough to embody these abstract concepts in a way that will accommodate and encompass everyone, which is precisely why the brain is a fascinating organ.

The brain controls emotions, feelings, and behaviors in the inner structures and different lobes of itself. The brain consists of different lobes. Each of them has a separate role in forming psychology.

The brain contains three different parts; the cerebrum, cerebellum, and brainstem (Figure 4) [14]. The largest portion of the brain is thought to be the cerebrum. It is located in the cerebral hemispheres, which are the left and right lobes of the brain. Areas in the cerebrum receive and give meaning to the pieces of information from the sense organs, and it is also essential for memory, reasoning, communication, emotion, and many other functions. On the other hand, the cerebellum is the coordination and order center of the brain. Although it occupies a minimal area compared to the whole brain, it is home to more than half of the total number of neurons in the human body

[15]. The brainstem is the part of the central nervous system that interconnects the cerebrum with the spinal cord.

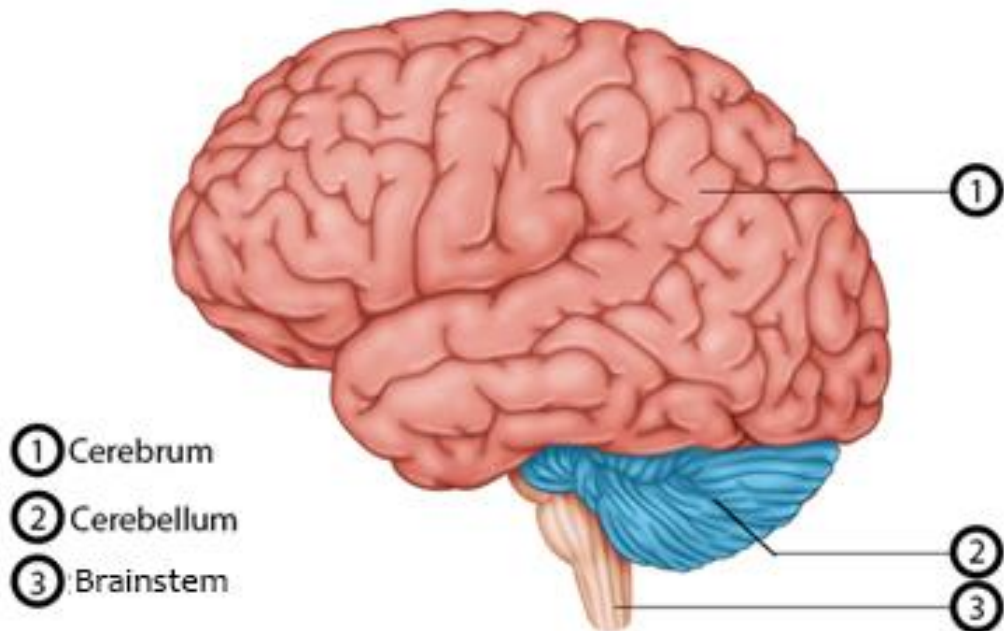


Figure 4: Cerebrum and cerebellum of the human brain and brainstem connection [14]

The cerebrum, the most significant part of these three structures that make up the brain, contains lobes that play a major role in emotions, feelings, and behaviors. Basically, there are five anatomic lobes that comprise the cerebrum: frontal, parietal, occipital, temporal, and insular (Figure 5) [16]. The frontal, parietal, and occipital lobes can be defined as lined up in a row, while the temporal lobe is located below the other three lobes. Also, the insular lobe is located within the cerebrum and is surrounded by the other four lobes.

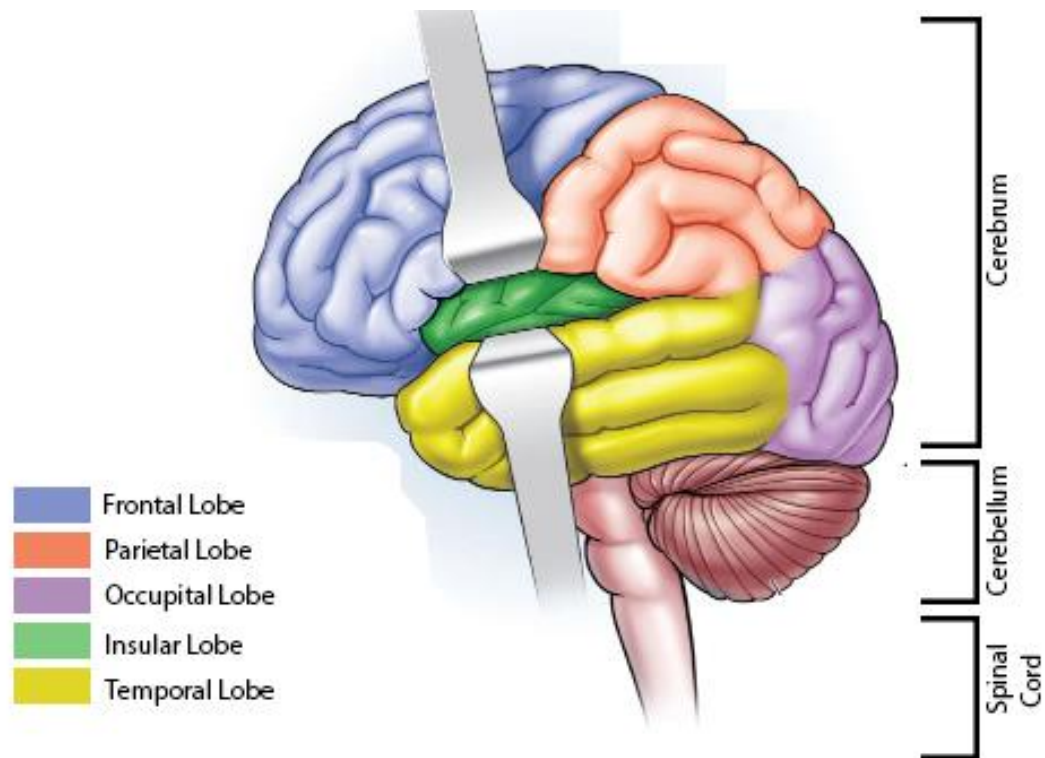


Figure 5: Lobes of the brain [16]

### 2.3.1 Frontal Lobe

The largest region of the cerebrum is the frontal lobe, which is situated in the front of the skull. The frontal lobe is an influential part of human psychology because of the systems it controls. The frontal cortex is important in memory, intelligence, concentration, temper, and personality. According to some references, the frontal lobes are considered the emotional control center, and home to one's personality [17]. The areas affected by the frontal lobe can be examined in two different sections. These are social-emotional reactions and cognitive skills. Among social-emotional reactions, decision-making, self-control, and emotional regulation can be counted as the main reactions that occur in the frontal lobe. Besides, cognitive skills are also controlled in the frontal lobe, which are concentration, high-level thinking, problem-solving, planning, and judgment. All these abilities are unique to the human brain and embody the emotional identity that distinguishes humans from other animals.

Since the frontal lobe causes many effects that affect human psychology, any damage to this part of the brain might cause psychological problems. Stroke is the most common cause of damage to a person's frontal lobe. Generally, during a stroke time, blood flow to veins in the frontal lobe stops momentarily and negatively affects the frontal lobe. If this is repeated more than once, it can lead to dementia [18]. Nevertheless, stroke is not the only thing that causes damage to the frontal lobe. Infections, brain tumors, or other degenerative brain diseases may also damage the frontal lobe. For the rest, psychology can affect the frontal lobe as well. Some research proved that mania, depression, confabulation, catatonia, perseveration, obsessive compulsion, and schizophrenia are the leading causes of frontal lobe damage [19]. In fact, these are such situations that they can damage the frontal lobe if they occur for other reasons [20].

### **2.3.2 Temporal Lobe**

Another essential part of the cerebrum is the temporal lobe. The human brain's temporal lobe aids in using senses to understand and respond to the environment around them. It is also the area responsible for how people communicate with others, how people retrieve their memories and, react to events. This is the lobe that makes humans feel emotions, senses, and recognitions. According to neuroscientists temporal lobe is most commonly associated with processing auditory information and certain aspects of visual perception as well. While all these functions occur in the temporal lobe, the three main tasks of the temporal lobe are listed by neuroscientists as follows; auditory stimuli, memory, and emotion [21].

For the temporal lobe to be damaged, a force such as a traffic accident or a hard fall is sufficient, and often after these reasons, damage to the temporal lobe is observed.

Different functions are controlled by different parts of the brain, and no two brain lesions result in the same reaction. Therefore, each person has a particular set of cognitive problems depending on the extent and location of the temporal lobe damage. If the temporal lobe gets damaged some things will be impacted negatively such as; processing sensory information, memory, language comprehension, facial recognition, spatial information, emotional regulation, and attention. All these deficiencies or problems are very effective in the psychology of people. However, when it is considered in the scope of architecture, what distinguishes this lobe from the others is that the person does not recognize and remember what is perceived, or even if it is perceived it can not be located in the relevant places [22].

### **2.3.3 Parietal Lobe**

This area also acts as a critical piece for many other areas to work cooperatively with many abilities people use throughout the day without even realizing it. It helps human self-perception and sensory integrations, learned movements, and even location awareness. Briefly, the parietal lobe is a central sensory processing hub for the human brain. Additionally, it creates a shape that is useful by combining data from several senses. In essence, it aids in the development of the brain's understanding of the built environment. This part is also vital for giving meanings to objects [23].

Damage to the parietal lobe can result in a wide range of issues due to its function in sensory integration, spatial reasoning, and language abilities. Damage to the parietal lobes can cause problems withdrawing, the ability to tell left and right, the awareness of certain body parts or surrounding areas, and other problems. Although this lobe does not directly affect the emotions and feelings like the frontal lobe, damage to the parietal lobe will cause deformations in the perception and sensation process of the space.

### **2.3.4 Occipital Lobe**

The rear of the head's occipital lobes controls visual perception, including color, form, and motion.

Damage to the occipital lobe might cause difficulty with identifying colors, locating objects, reading, and writing, or even damage to the occipital lobe that can cause visual illusions or hallucinations [24]. Vision deficits include blindness or blind spots, visual distortion, and visual inattention may result from injury to the occipital lobes. The occipital lobe, unlike the others, occurs with a physical change. While other lobes directly affect the psychology and mood of a person, the occipital lobe reveals visual changes or deficiencies and indirectly causes changes that might harm human psychology for a long time.

### **2.3.5 Insular Lobe**

This area of the cerebral cortex, which is located in a cleft close to the lower end of the lateral sulcus in primate brains, is not a lobe. It is believed to have a significant impact on mood -especially unpleasant emotions like disgust- taste, self-awareness, and motor regulation of processes like swallowing and voice articulation. It might also play a role in the control of procedural memory and cravings for addictive substances. The insular cortex, insula, and central lobe are other names for the insular lobe. Again, as with other lobes, inadequacies or damage in the aforementioned regions will result from physical or chemical alterations in this lobe.

These five lobes that make up the cerebrum have the power to damage the brain when exposed to chemical or physical damage in varying situations. Whatever the reason, these changes can affect people's psychology in different ways, either positively or negatively. For this reason, neuroscientific research on the brain is significant in order

to understand the effects of spatial phenomena investigated in this thesis on people's emotions, feelings, and behaviors.

## **2.4 Brain Lobe Triggers**

There are lots of situations that can be investigated and examined that are causing brain damage or brain changes. As mentioned in the previous chapter, the brain lobes work and fulfill their functionalities in different situations. For this reason, it is not very possible to affect or traumatize the whole brain for a single reason. On the other hand, it is possible to say that more than one lobe of the brain may be affected, especially if the brain has been exposed to situations like accidents, violence, etc.

In a research paper, a related case report is investigated. This study examined a 65-year-old man who had been feeling exhausted, low mood, and so tired that he could not do daily activities for the past two months. Prior to that, he worked for 40 years abroad and is seen as a very successful accountant in his job. He was traumatized and had a stroke after being scammed and losing all of his money and his home. At first, the doctors thought that he was depressed due to the trauma of the event and recommended antidepressants, but when the drugs were not enough for the treatment, a brain MRI was taken. As a result of the MRI, a left frontal infarct with compensatory left lateral ventricle anterior horn dilatation was the most notable discovery (Figure 6). A frontal lobe lesion is the most frequent cause of depression or other mood disorders since this lobe controls memory, emotion, judgment, executive processes, and behaviors [25]. A lesion of the dominant frontal lobe is more likely to cause these disorders.

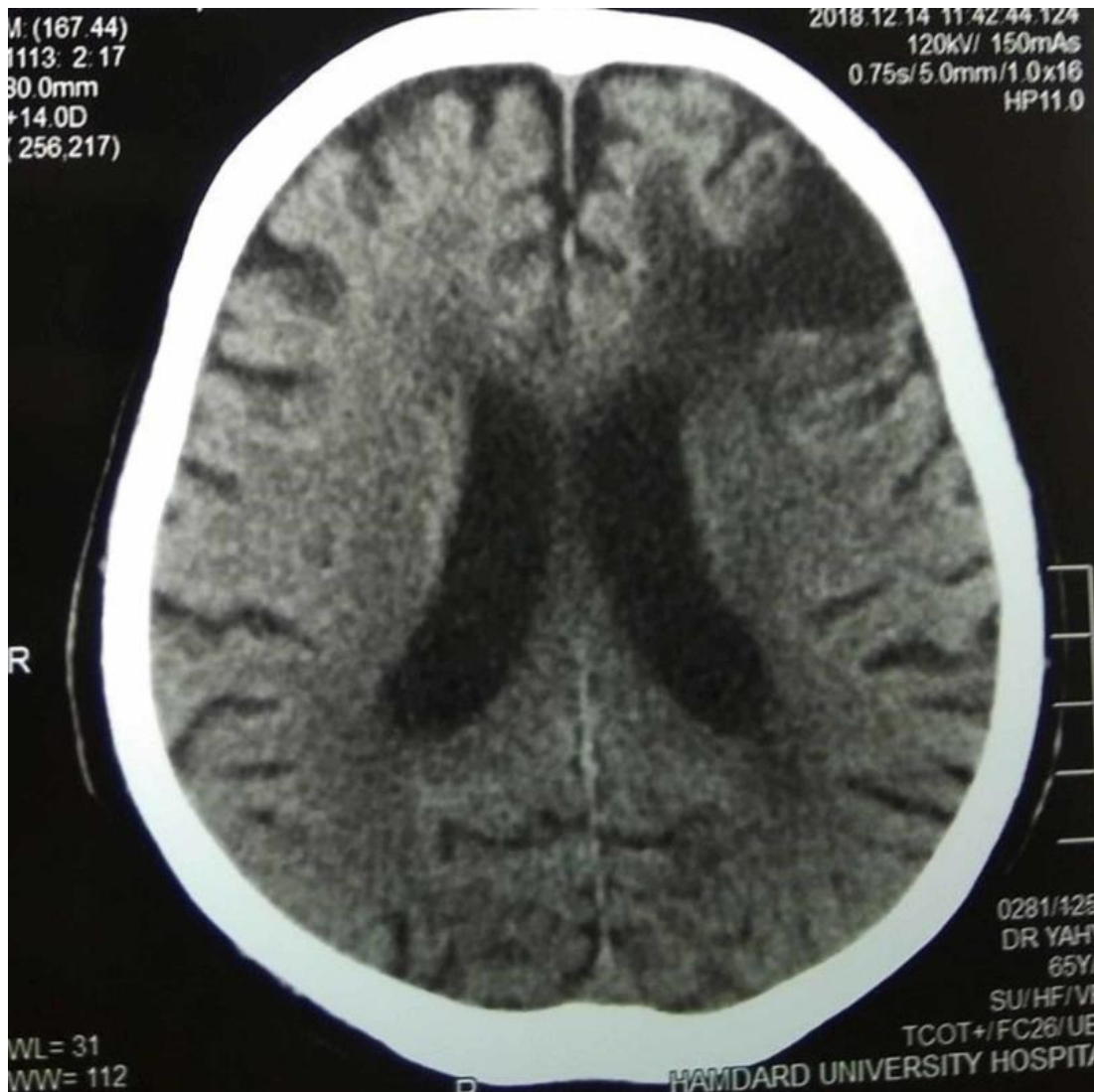


Figure 6: Scan of the brain, showing a left frontal infarct [25]

The patient was thought to be suffering from depression secondary to the loss of his savings and home; however, now it seems that his frontal infarct was, in fact, the cause of both his socioeconomic problems and his depression. As a result, although the mood changes of individuals can be psychological, they also require some physiological tests and examinations. As it can be understood from this case study, the factors that affect a person's mental health can be caused by changes in the brain.

Apart from the impact of physical damage, another factor affecting the working order of the brain is the hormones and enzymes secreted by the body. Of course, as it is

known, these enzyme and hormone changes can vary according to people's mental health situation. In contrast, the current situations or environment might affect the hormones or enzymes secreted in the human body and, thus, can change the perception, emotions, feelings, and behaviors in the brain.

Brain fog, one of the disorders caused by psychological changes in the brain other than physical damage, has been examined in detail in the following way. Basically, confusion, forgetfulness, a lack of attention, and mental clarity are symptoms of brain fog. Overwork, insufficient sleep, stress, and excessive internet use can all contribute to this. Brain fog is thought to be cellular-level inflammation at high levels and changes in hormones that control mood, energy, and focus.

Research shows that, incredibly, gender hormones play a role in memory, cognition, focus, and mental stability. For instance, low estrogen levels in women can result in mood swings, hot flashes, and attention problems. On the other hand, having excessive estrogen levels can affect memory. No matter the estrogen imbalance, muddled thinking can still result from it. Conversely, testosterone is created by the ovaries in women and the testes in men. By making the muscles in the neurons and arteries stronger, this hormone helps maintain mental clarity. Cognitive functions can be impacted by an imbalance of high or low levels of testosterone, which also indirectly results in hazy thinking. These hormones are the hormones that can be triggered in very limited ways in spatial formation. However, there are some hormones that suddenly trigger these hormones by feeling emotions such as happiness, sadness, or anxiety as soon as a person enters the place. Alternatively, some hormones are secreted in situations that occur after the use of the place for a certain period of time, and they have the authority to change the emotions, feelings, and behaviors of the person. One

of these hormones that will be investigated below is called cortisol. Cortisol is the stress hormone that operates a person's own built-in alarm system. It is best recognized for controlling the body's "fight" or "flight" reflex. A person may feel emotional and lethargic if their cortisol levels are out of whack. This imbalance might impair mental clarity and interfere with sleep. Increased cortisol levels brought on by lack of sleep can also result in brain fog at the end of the day and a vicious cycle.

Since people spend most of their days indoors in these times, spatial designs and architectural structures can affect human psychology and mood very quickly. At this point, it is essential to investigate the effects of hormones or physical damage on the perception of space, or vice versa, and how space design affects hormones in humans for this thesis.

## **2.5 The Emotional Brain**

According to the Oxford Dictionary, emotion is described as; "a strong feeling deriving from one's circumstances, mood or relationships with others." Or "instinctive or intuitive feeling as distinguished from reasoning or knowledge." [26]. In other words, in simple terms, the changes created by the things perceived by the five sense organs in the inner world of a person can be called emotion. Furthermore, these emotions can be categorized as positive or negative. Positive emotions can be divided into many branches, and negative emotions can be divided into many branches as well. Not everyone feels every emotion to the same degree and the dominant emotion varies from person to person. This change is very dependent on the environment, geography, and the built environment.

Russian anthropologist Paul Ekman put forward a study in 1970 that states that humans have six emotions, including surprise, fear, anger, joy, disgust, and sadness. Of course, this was not a situation that could be expressed superficially, and there were some researchers after Paul Ekman who argued there were four or even twenty-seven of these emotions in the studies carried out afterward [27].

No matter how different people are from each other, their anatomical brain structures are very similar. Of course, people's some lobes may be larger or smaller, but this is not enough change to break overall similarity. As mentioned earlier, emotions are perceived by the five senses, and these perceptions are then transmitted to the relevant parts of the brain and create human emotions.

Simply put, there are three brain structures that are mainly associated with emotions; the limbic system, the insula or insular cortex, and a structure in the midbrain called the striatum.

### **2.5.1 Limbic System**

In fact, according to research, it is said that the amygdala is the center of emotions. However, in order to understand the amygdala, it is necessary to examine the limbic system in which the amygdala is located. Because feelings do not occur in one place; they form in several places and merge in the brain. In order to talk about emotions, it is necessary to understand the limbic system in the brain first. The limbic system can be defined as a small but critical set of structures in the brain. This structure is described as the brain network system responsible for controlling emotional impulses and memory formation. In addition to hosting fear, anger, hunger, and sexual centers, it also carries out learning and remembering functions [28]. For this reason, the term ‘emotional nervous system’ is also used for the limbic system. The scientific world

continues its studies and naturally debates about which structures are included in the limbic system. However, according to current data, it is supported by many scientists the hippocampus, amygdala, thalamus, and hypothalamus are located in the limbic system (Figure 7).

Limbic system neural networks work with other brain structures to control various physiological and psychological functions, including emotion, behavior, motivation, memory formation, and sleep. Since the limbic system is also the structure that establishes the connection between emotions and physical reactions, the effects of architectural phenomena to be examined in this thesis on this system, or, the architectural perception processes depending on the limbic systems are crucial. If there is any problem in the limbic system, changes may occur in the person's behavior and emotions.

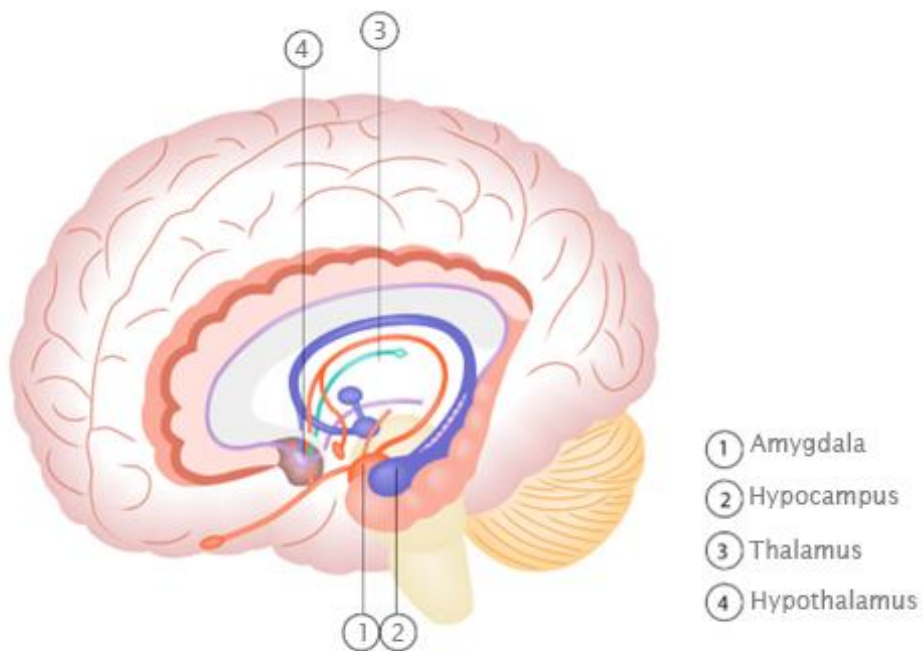


Figure 7: The Limbic System [28]

Emotional responses are shaped by the limbic system, excitement, anger, anxiety and other emotions [29]. The limbic system also connects emotions to numerous other mental functions, including learning and sensing.

## **2.6 Brain Chemistry and Psychology: Hormones**

Each individual's brain varies according to the hormones secreted in the body and changes affect the working mechanism of the brain. As known, the psychology of one is influenced by many things. Psychology is more complicated than the situations and environments a person encounters; there is brain chemistry to consider, too.

Basically, the mechanism is like, in between sensing, and responding to a situation, chemicals called neurotransmitters and hormones help the brain understand, evaluate, and communicate what a person is experiencing. These various neurotransmitters and hormones have specific duties, each being activated in a certain way, signaling certain emotions and stimulating certain brain areas. For instance, when it comes to psychology, in particular, the primary signaling chemicals are; serotonin, dopamine, and endorphins [30].

### **2.6.1 Serotonin: Happiness**

In Oxford Languages, serotonin is defined as ‘a compound present in blood platelets and serum, which constricts the blood vessels and acts as a neurotransmitter. Besides that definition, it is also known as the happy neurotransmitter because it is known as a hormone that causes positive effects on human psychology. A molecule called serotonin delivers information between brain and body nerve cells. Body processes like mood, sleep, digestion, nausea, wound healing, bone health, blood clotting, and sexual desire are all significantly influenced by serotonin. However, of course, since serotonin is known as the happiness hormone, it would be wrong to conclude that the

more it is, the happier one will be. It is deficiency causes psychological problems, and its excess has effects that will negatively affect the person's psychology.

Basically, serotonin plays several roles in the body, including influencing learning, memory, and happiness, regulating body temperature, sleep, sexual behavior and hunger. Lack of enough serotonin is thought to play a role in depression, anxiety, mania, sleep problems, obsessive-compulsive disorders, and other health problems [31]. Due to the low level of serotonin, the communication between the nerves in the brain of people struggling with stress or sadness is less. Serotonin spreads happiness signals to the brain by touching at least fourteen receptors. For this reason, it is a treatment method to increase the connections between the nerves and the brain of people who feel depressed (Figure 8).

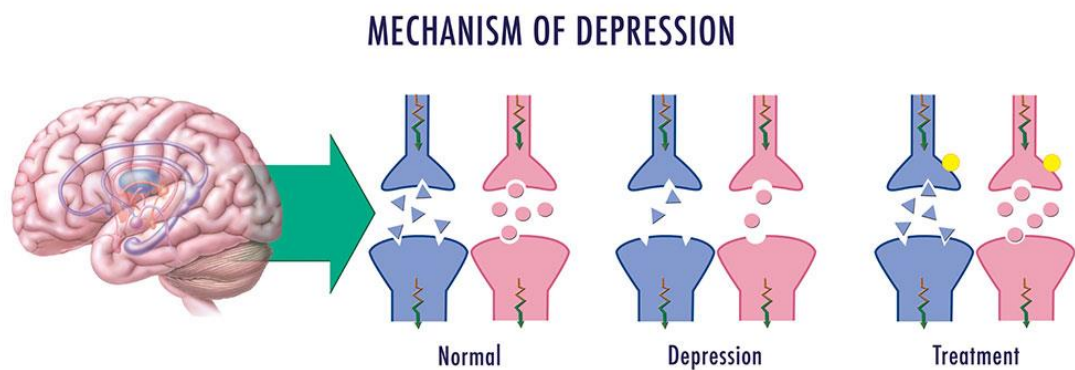


Figure 8: Mechanism of Depression [31]

Serotonin is a hormone often associated with vitamin D. The most natural way to increase vitamin D is to take advantage of plenty of daylight. For the prevention and treatment of vitamin D deficiency, natural sunlight supplementation as the absorption

of vitamin D will be better during the hours when the sun rays are high, between 10:00 a.m. and 3:00 p.m., and 15-30 minutes a day is optimal.

### **2.6.2 Dopamine: Motivation**

Dopamine is also called the “feel good” hormone, it plays a role in feeling happiness, pleasure, and reward, as well as the serotonin. Dopamine has a more direct effect on the neurons that underpin motivation and habit development than on the neurons in the brain’s “reward system” and the neurons that regulate sensations of pleasure. Dopamine encourages people to act in response to needs, desires, and goals. From an evolutionary standpoint, this system is designed to reward someone when doing the things they need to survive. Human brains are hard-wired to seek out behaviors that release dopamine in the reward system. If someone has the right dopamine balance, they feel happy, motivated, alert, and focused. If someone has a low dopamine level, they might feel tired, unmotivated, and unhappy. Just like serotonin, dopamine is also somehow related to vitamin D. So, for this reason, again, getting enough sunlight is important, and getting enough sleep also has a crucial impact if it is considered in the scope of the thesis. In this context, if it is thought of in terms of architecture, the importance of natural light, natural ventilation, and even artificial light sources on sleep quality should be examined [32].

### **2.6.3 Endorphins: Painkiller**

In the National Cancer Institute, endorphine is defined as “one of the several substances made in the body that can relieve pain and give a feeling of well-being. Endorphins are small proteins that bind to opioid receptors in the central nervous system. An endorphin is a type of neurotransmitter. There are more than twenty types of endorphins in the body. Beta-endorphins are the endorphins involved in stress relief

and pain management, and beta-endorphins even have a more substantial effect than morphine on the body.

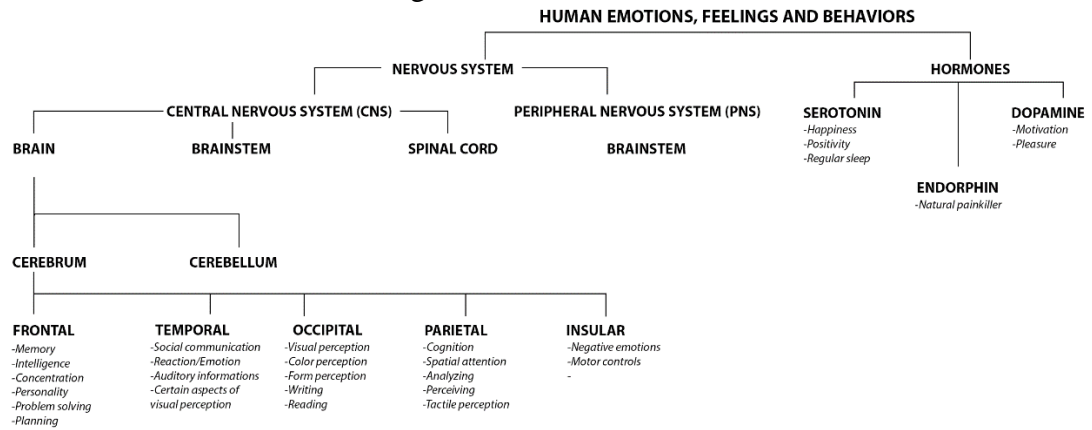
Basically, endorphins are released when the body feels pain or stress. The body releases endorphins to help people survive. When someone feels pain, the body's nerves send pain signals to the brain. The endorphins are then released by the brain to stop the nerve cells from receiving pain signals. In essence, this stops the pain. It enables people to function even under trying or painful circumstances. People are more inclined to act if it makes them joyful since they naturally try to avoid pain.

Endorphine has many benefits, just like serotonin and dopamine. Studies have shown that it can help in the following ways; easing symptoms of depression, helping with stress and anxiety, and improving self-image. Research suggests that the easiest way to release endorphins is by exercising. The more people exercise, the more endorphins the body will produce. For instance, many people feel a 'runner's high syndrome' after a good run. However, people do not have to run to feel this feeling. Other forms of increasing endorphins still exist, such as creating art, meditation, aromatherapy, and listening to favorite songs. In other words, endorphin is a hormone that appeals to the abstract brain of a person. The five sense organs of the human can be used to make people release endorphins in places. In this thesis scale, music, smell, colors, patterns, textures, or shapes of the objects can change people's psychology by affecting the level of endorphins secreted [33].

The topics examined under the sub-heading reveal the connection between neuroscience and psychology and the effects of the human brain on the perception and feeling process. Since the brain is a very complex structure, the reasons affecting

psychology cannot be shown on a linear plane and they branch out within themselves (Table 2).

Table 2: Human Emotions, Feelings, and Behaviors [14]



The brain controls all functions of the body, interprets information from the outside world, and defines who the person is as an individual and how the person experiences the world. The brain receives information through the senses; sight, touch, taste, smell, and hearing. This information is processed in the brain, allowing people to give meaning to the input it receives. In other words, since everything that is felt is formed by passing through the sense organs and the brain, all these have a great effect on emotions and behaviors. It can be said that it directly affects our psychology. For such reasons, neuroscience and psychology disciplines are very important in the architectural design process to be able to make user-oriented designs.

## 2.7 Brain and Perception Process

As it is written in the Oxford Dictionary, perception is defined as “The ability to see, hear or become aware of something through the senses” and also “The way in which something is regarded, understood or interpreted. In other words, perception is the

whole conscious reactions aroused in the brain by the data that are chosen to be perceived”.

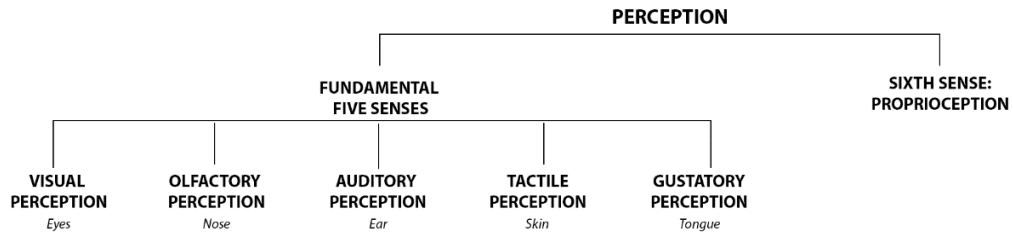
As known, people experience the spaces by using their senses, they explore spaces, and over time they learn how to behave and act in different spaces. All these situations depend on how the environment is perceived.

The process of transmitting the perception in question to the brain passes through five sense organs. These five sense organs are the tangible methods of perceiving space.

The neuroscientific study also analyzes proprioception, which controls the sensation of orientation and balance in space, in addition to the conventional five senses [34].

Basically, the proprioceptive sense allows people to perceive the position of the limbs, the sense of movement, strength, effort, and balance in the absence of vision and inattentive perception. It plays a crucial role in everyday life, contributing to the ability to interact successfully with the environment along with motor skills. Even proprioception is often referred to as the “hidden” sixth sense. The reason why this sense is called hidden is that people use it all the time without realizing that they have this sense (Table 3). And the receptors of this sense do not have a central organ such as the eye or ear. So, the perception process of the built environment is changing from one to another. The built environment is generally related to architecture and urban planning, and more importantly, it is substantially related to anthropology, sociology, psychology, and other public health disciplines as well.

Table 3: Perception Types [34]



As mentioned in the previous chapter, emotions, and behaviors affect some parts of the brain or may change in line with some parts of the brain that are affected somehow. These behavioral and emotional changes also directly change the perception. Spatial perception is also directly affected by these changes or causes these changes. In other words, the places people live have a considerable impact on their psychology. While some spaces add to the anxiety, others provoke a sense of serenity.

It is said that all these emotions and behaviors are directed to the receptors related to our five sense organs and the sixth emotion called proprioceptive. The critical point is to examine how the perceptions of the brain and human behaviors and emotions, that is, human psychology when viewed holistically, are related. Exploring some of the basics of psychology means looking into the biological processes that play a role in how to perceive.

It can be concluded the ability to perceive is crucially essential for humans. Because it activates the impulses of people to make decisions or behave appropriately, without these perceptions, a familiar face turns into a combination of colors and shapes. Or even a burning food and a fresh strawberry will smell and taste the same. In other words, perceptions are critical in defining simple or important events in our lives, making decisions, and acting according to them.

According to one research, information selection, organization, and interpretation are all parts of perception. This procedure entails the perception of inputs that go via our perceptual filters, are arranged into pre-existing structures and patterns, and are then interpreted in light of the experiences we have had in the past. So accordingly, people attribute different meanings to the people or objects they see and give different reactions. Regarding this statement, it is possible to say that, perception consists of three main stages and scientists have already preferred to analyze the perception process by dividing it into three processes. This thesis will examine these processes under the following titles; selecting information, organizing information, and interpreting pieces of information. While investigating these processes, it should be taken into account that the selection, organization, and interpretation of data differ from one person to another.

### **2.7.1 Selecting Information**

People perceive phenomena through their five senses. They see, hear, smell, taste, and feel many phenomena during the day, but only some of them form the instinct of transmitting data to the brain. Basically, they tend to pay attention to salient information. Saliency is the degree to which anything in a piece of content draws our attention. The things that catch our attention can be concrete -like an object- or abstract, like a notion. Fiske and Taylor conducted a study and came to the conclusion that visual and aural stimulation, needs and interests, and expectations all affect saliency to varying degrees.

The first factor is visual and aural stimulations, defined as attention-getting in a productive or distracting way. An example of this is anything that distracts and disturbs

while busy with a task. A color of clothing, a smell from the surroundings, or even a few loud people at the following table will be enough to draw attention and distract.

The second factor is called needs and interests. People can make selective perceptions in order to satisfy their instant needs. For instance, a driver who runs out of gas while on the road will have a more perceptive attitude toward gas station signs and advertisements in order to meet this need.

The last but not the most minor factor is expectations. This factor arises from the state of constant vigilance due to the possibility of the expected situation from a phenomenon over a period of time. For instance, if a cargo that should arrive at any moment is expected, the clicks coming from the outside should mobilize a person quickly. This would be the best example to explain this situation.

A person's perception can be affected based on any of these three conditions. However, the important thing here is not how people perceive and notice things, but how those perceptions are processed in the brain.

### **2.7.2 Organizing Information**

According to Coren, humans simplify pieces of information and look for patterns to help them communicate more efficiently and get through life. It's not always harmful to simplify and categorize based on trends. In fact, without this, it's likely that humans wouldn't be able to speak, read, or perform other complicated cognitive and behavioral tasks. Different areas of the brain are in charge of handling various sensory experiences, and the human brain has an inbuilt ability to organize and store data and experiences for later retrieval. In other words, it is natural for objects to cluster and search for patterns that benefit humans in a variety of useful ways.

Some studies say that people make the grouping according to some gestalt rules and three basic categorization methods are; similarity, proximity, and emphasis. Similarity can be described as the human eye tending to build a relationship between similar elements within a design. Similarity can be achieved using basic elements such as shapes, colors, sizes, etc. Proximity, on the other hand, states that people perceive objects which are close to one another as a group. This is true even if the color, size, or shape of the objects differ. In some references, it has been mentioned that the principle of proximity is stronger than other gestalt principles. Finally, the emphasis is that some objects have features that stand out from the others. This too can be created by color, size, and shape.

Of course, it should not be forgotten that the culture raised in the process of organizing this data is also of great importance. Liang-Hwang Chiu made a very critical, and striking experiment related to this. In this experiment, children from China and the United States were given three objects (a chicken, a cow, and some grass) and asked to group any two of the objects that belonged together (Figure 9) [35]. The majority of American schoolchildren selected the chicken and cow, citing the fact that they were both animals. The majority of Chinese children, however, for cows and grass, claim that cows consume grass. The causes of this have been attributed to variations in cultural origins, which foster various cognitive philosophies. People from East Asia are frequently motivated by interdependence, harmony, and relatedness. The tendency of Westerners is toward independence. People who are interdependent think about things in connection to context, whereas independent people often concentrate on categories with shared characteristics, such as animals.

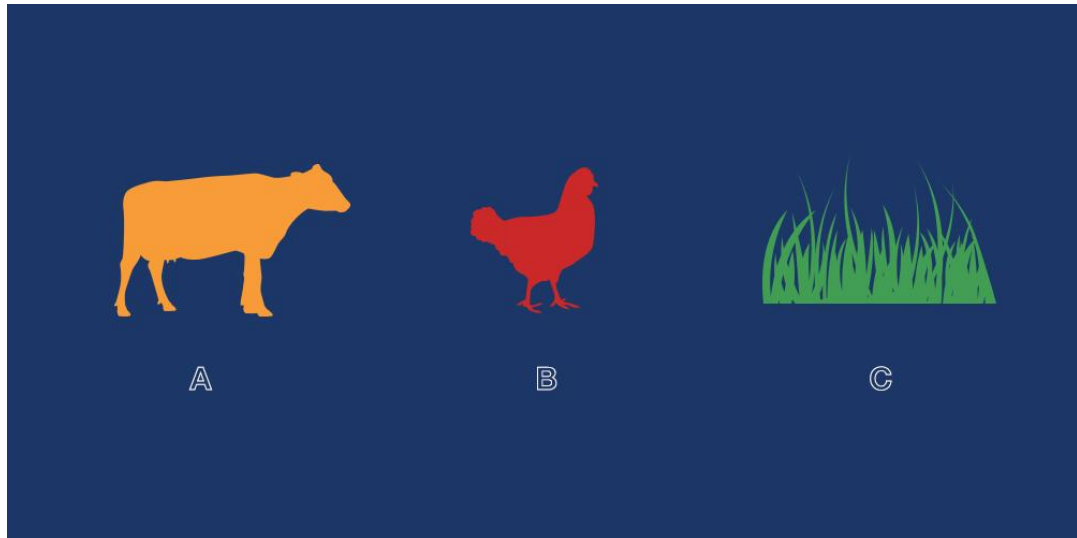


Figure 9: Information data experiment visual [35]

### 2.7.3 Interpreting Information

Interpretation is the third part of the perception process, in which people assign meaning to their experiences using mental structures known as schemata. Selecting and organizing processes are phenomena that take place in a short time.

However, the interpreting process can be described as the most complex and lengthy process of perception process. This is a process that not only receives the data but also evaluates it as a result of experiences and knowledge, and is also processed by using memory. For example, assume someone learned about different symbols and objects and concepts like a calculator, notebook, or grades are associated with being a student. As progressed through education, schema adapted to the changing environment.

### 2.8 Factors Affecting Perception of Brain

A cognitive process called perception is used to comprehend and evaluate the information that people receive from their senses. A number of other factors, such as emotion, motivation, culture, and expectations, can also have an impact on perception. These are all contexts that can change depending on the culture, needs and desires,

previous experiences and memories. In other words, it is very difficult to present concrete data about these, especially for professions that try to influence human psychology through physical factors such as architecture. But on the other hand, it is possible to find a few facts that affect human perception and are not based on personal data. We can also divide them into two; psychological factors, and external factors [36].

### **2.8.1 Psychological Factors**

Psychological factors can be defined as some events that develop and grow people. For instance, memories from the past, upbringing, circle of friends and family, education received, etc. Psychological factors that cause differences in people's perceptions. All these mentioned phenomena form the interests of people. And this is primarily a topic about human interest. People tend to perceive mostly what interests them. This applies anywhere from a person to an animal or an object to a built environment. In order for people entering a space to enjoy the elements in the space, events that can attract attention according to the function of that space should be used. Otherwise, when people who come to the venue for a specific purpose cannot find what they are looking for, their mood will change negatively.

It is generally believed that intense feelings and situations, such as stress and anxiety, can affect how much and what people perceive. Feelings of happiness or sadness can influence how stimuli are seen; when feeling down, people may notice things that are more hurtful. Additionally, depressed individuals are more susceptible to optical illusions. On the other hand, social norms, rules, beliefs, and standards set by the society/culture people live in, can affect the perception as well. For instance, research evidence has found that people living in Eastern (collectivist) societies tend to perceive

things holistically. Such as seeing objects about others. Whereas, western (individualistic) societies tend to perceive things analytically.

### **2.8.2 External Factors**

External factors, on the other hand, are the situations arising from the changes that occur in a person's emotions and situations in a short time. For instance, situations such as hunger, insomnia, fatigue, illness, depression, anxiety, etc. can be given as an example of the external factors that affect human perception.

Gilchrist and Nesberg (1952) investigated if hunger had an impact on how individuals viewed food. 26 students who volunteered to participate in the study were involved. One group (the experimental group) was not permitted to eat for 20 hours before the trial, while the other group (the control group) was permitted to eat normally. The screen would show a picture to each group for 15 seconds before going dark. Participants were also informed that the same image would be repeated for 15 seconds. The experimental group saw things differently; they were informed that the brightness had altered. Little change in memory accuracy of image brightness was seen in the control group. The experimental group evaluated the pictures as their hunger increased. As a result of this experiment, the effect of external factors on human perception has been studied and seen to a large extent [37].

## Chapter 3

# ARCHITECTURAL PERCEPTION AND IMPACTS ON PSYCHOLOGY

According to the Oxford Dictionary, architecture refers to ‘‘the art or practice of designing and constructing buildings’’. In most basic words, at its roots, architecture exists to create the physical environment in which people live. Architecture is more than just the built environment, it is also a part of the psychology. It stands as a representation of how people see themselves as well as how they see the world around them. Architecture is a tool that can be used not only to build roofs on top of people but also to make them feel belonging in the space or to make them feel happy and safe in different ways. Human perception has long been a critical subject of design thinking. According to a recent study, people should feel supported psychologically by the built environment. The term "psychosocial" refers to the interaction of behavioral and social elements and their impact on a person's mind or behavior, according to the Oxford English Dictionary. Values, interests, and self-concept make up a person's psychological skills. Defining ideas or beliefs that are significant to oneself and others is what is meant by values. The identification of mental or physical activities that are pleasurable and keep attention are referred to as individual interests [38]. An individual's social skills include self-expression, interpersonal communication, social behavior, and role-playing. Role performance is defined as recognizing, upholding, and balancing functions acquired in society. Social interaction is defined as engaging in behaviors such as etiquette, respect for others' space, eye contact, gestures, active

listening, and self-expression that are appropriate for the situation. Whether individual or social, these psychological abilities change the spatial perception mechanism of people. Changing factors in the perception of the built environment, of course, can cause some changes in the brain lobes that have been explained in detail in the previous chapters, and can cause changes in the hormonal balance as well. Some studies show that the places people live in make people secrete different hormones. These hormones also depend on factors that vary according to the built environment if it is considered in the scope of architectural psychology.

As mentioned, there are three different hormones known as happiness hormones. Factors affecting these hormones have been reviewed in the previous chapters. It is known that everything seen, heard, and felt, in short, affects these hormones in some way. Some of the important variables in the secretion of these hormones are air quality, natural or artificial lighting, colors, and materials.

### **3.1 Architectural Psychology**

Anything that happens in the environment plays a role in influencing human feelings and emotions because, in some way, people tend to see what they want to see and to hear what they want to hear. So, a person's behaviors and feelings are always impacted by the places they go or stay. Therefore, since people spend most of their days indoors, they are exposed to architectural structures and designs a lot. At this point, architecture has a great role in human emotions, feelings, and behaviors, as it changes and affects the form, function, and design of the spaces. This branch of research, which is formed to examine the effects of a building on human behavior and emotions, is called architectural psychology. In addition, according to Psychology Dictionary architectural psychology is defined as "The study of built environment on human

behaviors. This represents a major subtopic in environmental psychology, also known as design and behavior”.

Architectural psychology, or the study of how human behavior changes in response to circumstances and other factors. Throughout history, the ancestors of man have also built spaces suitable for human life, psychology, and behavior, although they do not have today’s technology. But when ancestors were doing this back then, they did not realize that it was a science and that it released hormones that change people’s psychology in a good or bad way.

The origin of the field dates back to the beginning of the 20th century in Germany. A psychologist called Hellpach is said to be the first to use and define the term ‘Environmental Psychology’. In his first book, he studied the effect of the sun and the moon on people’s psychology and behaviors. Besides Hellpach, Hans and Martha Muchow were also interested in environmental psychology, specifically psychology concerning children and young adults. Of course, apart from these, a lot of research, especially in the European region, has contributed a lot to this branch (Figure 10) [39]. Although these studies are called environmental psychology, they can be considered as a precursor to ‘Architectural Psychology’.

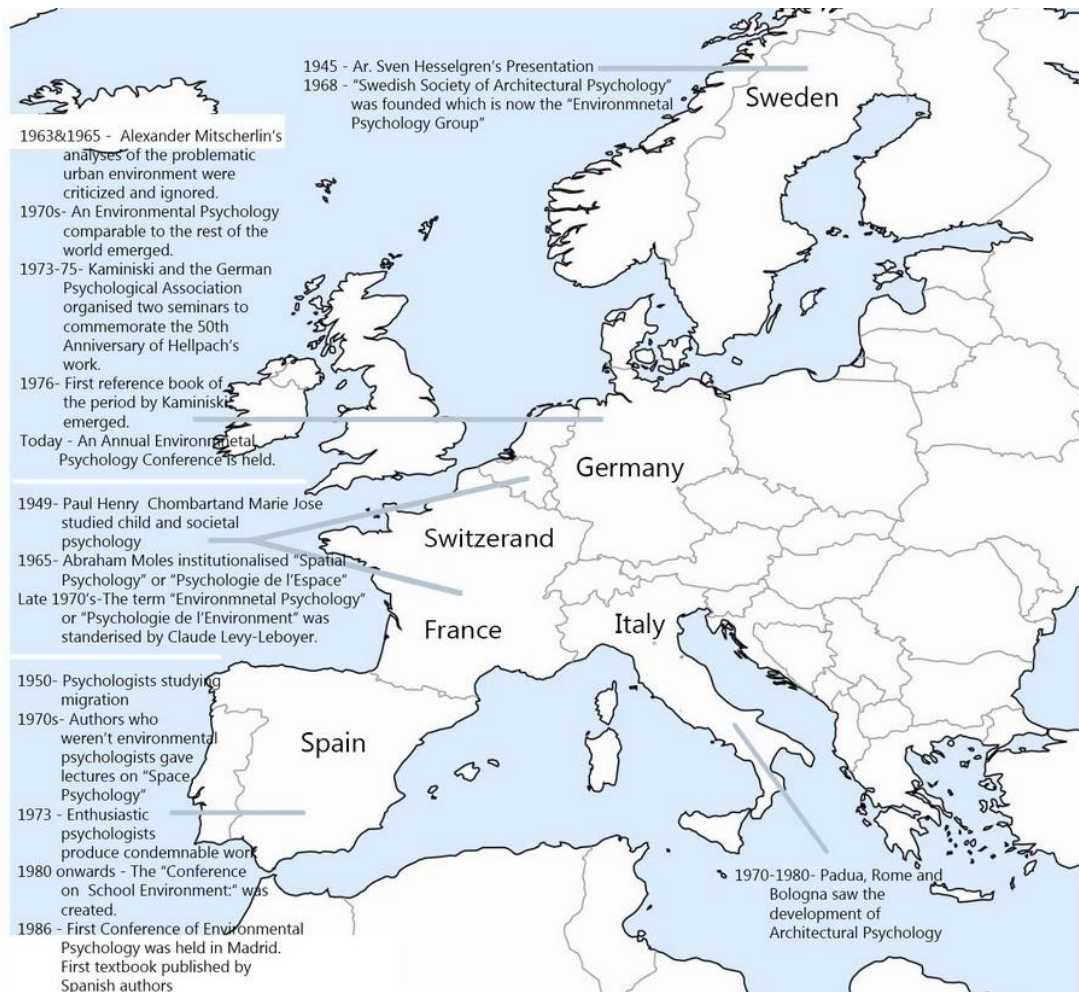


Figure 10: European Countries that Contribute Architectural Psychology Discipline [39]

As a result of all these researches, scientists and authorities in the field developed a new branch of research and called it "Architectural Psychology". The first was the focus on building more practical and comfortable settings, and the second was the serious misunderstanding of the terms "ecological" and "environmental.". Initially, in North America, the consolidation of Architectural Psychology was brought about by working on spatial behaviors, especially in psychiatric centers and hospitals. According to the data found as a result of this research, it was concluded that the psychology of the people in the space was affected by some factors or that their psychological states were effective on people's perception of the space. People who

do research on architectural psychology have also investigated how the brain is affected by these situations and argued that human-oriented design studies should be increased. Training should be received on these topics. Architectural psychology is not only practical on human psychology, emotions, and feelings but also argues that people can change or direct their behaviors and movements in a space. Human reaction to the built environment can be influenced by tweaking and balancing certain factors to impact action and behavior in a space. Every choice made through a design is reflected in the perception and eventual behavior in the space.

So in sum, the research field called “Architectural Psychology” deals with the relationship between sensory experience and architectural perception. Among these sensory experiences, for instance, visual information plays a crucial role in shaping the manner in which people represent and interact with the world around them. In fact, for those who are seeing, vision is so widespread that it is difficult for them to envision a world without their eyes. In particular, despite the fact that vision provides distinctive and singular pieces of information, a number of data suggest that vision may not be absolutely necessary to develop an accurate mental model of the world. In fact, people who have been born blind exhibit cognitive, social, and perceptual abilities with those of sighted people. For instance, Peter Eckert is a photographer, Chris Downey is an architect, and Esref Armagan is a painter, and all three of these individuals are blind yet are completely capable of carrying out their professional lives successfully.

As mentioned earlier, perception is felt through the five senses. If a person has a congenital loss in any of these senses, scientists argue that this person will not feel any deficiency in the perception of space. On the other hand, scientists say that a person who has lost one or more of the senses, although he had no problems with his senses

before, will lose some of the spatial perception. Because each sense organ sends signals to different parts of the brain. The brain, which is accustomed to receiving these warnings, becomes confused after a while when it cannot receive signals anymore from one organ.

As a result, a quote from Dr. Morgan Williams, who is a licensed clinical psychologist and licensed architect at the same time, will explain and reveal the facts about architectural psychology ‘‘ Many people then underestimate the contribution of the physical environment to their overall level of life satisfaction. Nevertheless, the current scientific literature confirms the profound impact that one’s physical environment can have on thoughts, emotions, and behaviors. The study of these interactions between humans and their physical environment is referred to in many different ways, but most frequently as a unique field that combines relevant theoretical aspects of both in order to enhance the human experience. Architectural Psychology effectively bridges the gap between architecture and psychology’’ [40].

In actuality, architectural psychology is the study of how individuals interact with the environments they use. Lighting, colors, arrangements, scale, proportions, acoustics, materials, and more all appeal to the senses of the individual and elicit a range of emotions. As a result, design and creative measures should be taken into account in accordance with the social and psychological needs of occupants. This can range from including welfare and safety to defining well-being or creating a positive and efficient working environment. This is referred to as experiencing space from various angles. Human brains have developed to experience not just of their body’s position in space, but also of the objects in their immediate vicinity known as the peripheral space. This ability allow people to efficiently grasp or interact with the objects that surround them

and serves to protect them from harm. The first of these phenomenas appeared in the late 1990s. Researchers at Princeton University examined the monkeys' brains and discovered that neurons in the parietal and frontal lobes produce electric signals whenever an object comes close enough to any area of the animal's body. The monkeys adopted their distinctive movements when these neurons were stimulated. Patients with strokes in the right posterior parietal lobe report that they are unable to perceive peripheral stimuli on their left side of the body, but can "sense" objects farther away on that side. These trials were never reproduced on people. In other words, it was determined from this experiment that the human brain functions similarly to the monkey brain.

Fundamentally, it is discussed how people move through space and behave in it. Space can also be experienced sensorily. The nature of the movement is frequently determined by the nature or purpose of the space. In contrast to a vast hall, which offers much more variety in movement or stasis, a long, narrow corridor will facilitate passing through but will only offer minimal encouragement to linger. Moving from one space to another can have an equal impact on the experience. Moving from a small to a vast space might evoke sensation or wonder, whilst moving from a large to a tiny space can be either reassuring or menacing.

The way that people with impairments use environments gives the architectural design a new perspective. There are many distinct levels of visual impairment; some people are completely blind and must rely on other senses, while others have varying degrees of clarity, small fields of vision, or are extremely sensitive to light and brightness. Users of wheelchairs will view the area from a lower perspective than those who are mobile. The aural world will also be experienced differently or maybe not at all by

people with hearing problems. For instance, those with eyesight issues could not experience the emotional changes brought on by the changes in the previously described location. When moving from a noisy location to a quiet location, certain individuals who have hearing impairments might not notice it either [41]. At the end of the day, all this causes physical differences in perception.

Except all of that, as with just about everything in life, how people experience architectural space is an incredibly personal thing, and frequently something people are not aware of. Changes in climatic conditions, daylight, sunlight, night time even moods can influence people's perceptions and psychology as well. On the other hand, when neuroscience and architecture combine and work in cooperation, it is possible to put this on a more scientific level. For example, it has been stated in the above sections that hormones like dopamine, serotonin and endorphins released in the brain make people happy. Some phenomena felt by the five sense organs also affect human psychology by causing hormonal changes in the space design and perception processes. Everything that falls into the perspective of a person affects hormones and indirectly the brain. For instance, the common assumption is that color is no more than a decoration and can simply follow trends, but this is absolutely false and counterproductive. While some colors make people happy, others can make them feel depressed. Or, the excess of objects around may make some people uneasy, while the few objects create a safer environment for some people. These five sense organs and the effects of human psychology will be discussed in the next section in coordination with the neuroscience branch. Architects must consider the senses of every element of a building's construction from the earthy colors of primary construction materials like wood, stone, brick, and marble, to the expansive variety of colors available for paint,

doors, windows, siding, and trim. If all architectural aspects meet with neuroscience, it is possible to create spaces in which the user will be quite satisfied to be in.

Decision-making mechanisms are important factors affecting the architectural design process. It is possible with architecture to move a person in closed or open spaces or to interfere with all the movements in some way.

Every day, everyone makes hundreds of decisions. Most of them are little, such as choosing what to eat, but some are more complicated and entail evaluating the potential rewards and expenses, such as determining whether to focus on your studies more for a better life rather than spending time with friends. These types of decisions are influenced by an individual's values and interests, but it is still unclear how human brains generate these decisions. The Okinawa Institute of Science and Technology Graduate University's researchers have now discovered a new region of the brain that may be involved in cost-benefit analysis. Many neuroscientists formerly held the belief that each region of the brain performed a particular function, such as facial recognition, memory, or movement. But in more recent years, we have come to understand that it's far more intricate and that cognitive functions are carried out by a distributed network across the brain, with numerous brain areas communicating. author Dr. Bianca Sieveritx, a former doctoral student who is currently a junior research fellow in the unit that studies brain mechanisms for behavior. In order to completely comprehend how cognitive processes like decision-making function, scientists must first identify the connections between the various brain regions. Of course, it's difficult to chart the links. 'Each neuronal sub-class may only connect to one other area of the brain or be involved in one particular function, and there are numerous different types, or sub-classes, of neurons inside each brain region. You must be able to recognize these

different types of neurons. So it is highly disorganized and challenging.” Explained Dr. Sieveritz [42]. According to Dr. Sieveritz, the most important links in the brain to be able to make decisions are the thalamus and the limbic system. Interestingly, Dr. Sieveritz noticed that neurons from the thalamus send signals to inhibitory neurons within the limbic system. These inhibitory neurons slow down or completely stop neurons from firing and are essential for keeping the brain’s activity under careful control. Dr. Sieveritz stressed that while her results implicate the thalamus in decision-making, further research is needed to uncover its exact role in this cognitive process. Lastly, Dr. Sieveritz mentions “Neuroscience is like a huge jigsaw puzzle, everyone can only do a tiny part. But when all our research is combined, hopefully, we will start to see the bigger picture”.

Besides that, the building of diverse decision-making models utilizing various types of neural networks has received a lot of attention in recent years. Most scientists are aware that the prefrontal cortex, which controls working memory, and the hippocampus, which controls long-term memory, interact to produce the decision-making process. However, there are other parts of the brain that are crucial for decision-making, albeit it is still unclear exactly how they work [43]. As mentioned, the decision-making mechanism and process are quite complex. However, there are some generally accepted views. In order to better understand the decision-making process, scientists have divided it into some sub-titles. According to psychiatrists, decision-making is divided into two; rational and intuitive. On a very basic level, they stated that rational decisions occur on the left side of the brain, and intuitive decisions occur on the right side of the brain. According to psychiatrists, the left brain is

responsible for logic, organization, administration, detailing, facts, and science; while the right brain is responsible for emotion, spirituality, art, belief, and interpersonalitv.

The rational model of decision-making is based on the assumption that people have all the relevant information, can weigh the pros and cons of each alternative, and can choose the optimal solution. This methodology uses a logical and systematic approach to define the issue, produce and assess alternatives, and then execute and monitor the selected solution. This paradigm has the advantages of being visible, consistent, and impartial. It can help people to avoid biases, errors, and emotions that might cloud their judgment [44]. An example of this decision-making method can be given by a student whose university exam result is announced and who has to choose a university. While making this decision, this student has to question one by one the city to move to, the price to pay, the quality of the education, and the expectations from life. This is an important decision that will guide one's life and there is no chance to take this decision according to the instincts and risk it. Decisions should be made within the framework of logic, by taking advantage of people who have gone through this route before and the comments of students studying at the university.

Also, this rational decision-making process can be transferred to architecture as well. To explain, an example can be given to two friends arranging a meeting outside. If one of them is hungry, a place with good food smells and tastes will be preferred. Or if one is tired, a dim and quiet place will be preferred. Or if one's financial situation is not good, a cheaper place will be preferred. It is quite easy to multiply and extend these examples. From a spatial point of view, rational decision-making influences spatial choices, even if it is not of vital importance. People choose the places they will be in, according to their own decisions, their budgets, psychological states, and emotions

have the power to change these decisions. For this reason, the perception that places leave on people is also effective in this decision-making process [45].

The intuitive model of decision-making is predicated on the idea that people depend on instinct, experience, or their gut to make snap judgments. In this methodology, problem-solving, tacit knowledge, insight, and intuition are used in a less structured and more flexible manner. This paradigm has the advantages of being quick, flexible, and inventive. It can help people to cope with complex and uncertain situations, where information is scarce, ambiguous, or conflicting. It can also tap into one's brain's subconscious and emotional intelligence, which can enhance decision quality and satisfaction [46].

### **3.2 Visual Perception and Psychology**

The brain's various active areas work together to support the vision. However, the visual cortex is a structure located in the occipital lobe that receives nerve impulses fired by rods and cones through the optic nerve. The image of the object is processed by the occipital lobe. Following that, the parietal lobe receives the visual information, which is in charge of providing awareness of the physical distance between people and depth perception of the item. The temporal lobe, which is connected to memory, also receives visual information. What humans observe has meaning because of the temporal lobe. Additionally, there is proof that the frontal lobe, the brain's reasoning or thinking region, participates in the process of vision. The ability to stay focused is controlled by the frontal lobe.

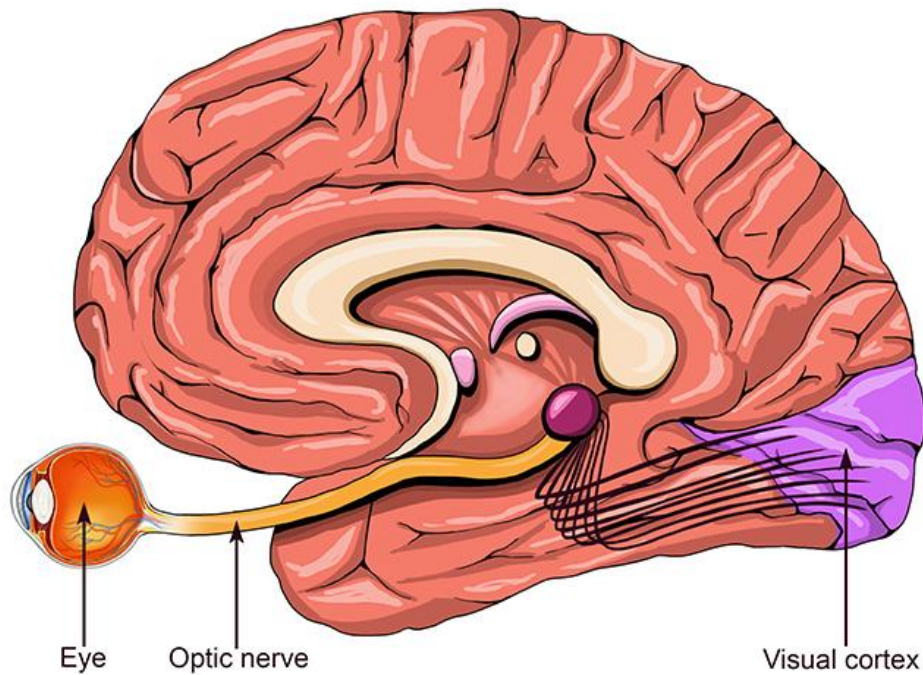


Figure 11: Vision process in the brain [47]

The processing of vision is therefore an extremely challenging task for the brain. The fact that the optic nerve and brain are both connected to the eye, which is where all visual information travels (Figure 11) [47].

Vision is a phenomenon that greatly affects human perception and emotional state. Vision, which is a very important element in architecture, and should be considered for its use, offers the people in the space, the opportunity to have good experiences when it is designed correctly. For this reason, vision should be examined in detail with the changes that affect it, and its effects on humans should be investigated.

There are several factors that will affect the visual cortex and change human psychology in space, the most important of which are the colors and lighting of the space.

### **3.2.1 Colors**

Because the visual system accounts for 80% of all sensory perceptions, color is a significant stimulant for the brain. According to certain studies, the pituitary gland, which regulates body temperature, energy level, sleep pattern, metabolism, and sexuality, is sensitive to the stimulation of colors. Contrary to popular belief, color has more uses. They have the power to alter mood, energy level, sleep cycle, blood pressure, and even sexual function. Colors are distinct lengths of light waves that have an effect on humans even when their eyes are closed. As a result, the colors in the constructed environment should be considered.

Additionally, colors can raise arousal levels and improve visual memory. According to certain studies, psychological arousal was higher while viewing the color red than it was when viewing the color green. On the other hand, some colors will help people focus. Therefore, understanding how to use them is crucial. For instance, the color white, which is frequently used in public places and educational institutions, can reduce focus and raise tension.

When making decisions, the human brain heavily relies on emotions and feelings. Knowing the feelings the target audience identifies with each color can be useful.

Warm hues, (yellow, orange, pink, and red are examples of warm colors) that can inspire and energize individuals, and enhance concentration, memory, and performance. Clinical research demonstrates that the color red affects memory function by heightening attention and arousing emotional responses to the subject matter. Warm colors also appear to stimulate the survival mode, enhancing force and haste while reducing patience and creativity and making people bustling in the design of the space. According to a study, it was discovered that factory workers work more

quickly and productively while working in red-painted rooms. But on the other hand, this productivity can turn into a state of panic and stress in designs where the color red is used a lot. Because the color red can activate some emotions that mean danger or error in people. Another experiment on this was tried on children who were going to take an exam. Children waited in the waiting area for 15 minutes before entering the exam hall. One group of students waited in the white-painted room and the other group of students waited in the red-painted room. After the exam, when the test results were examined, it was found that the students who were kept in the red room left the exam earlier and their results were worse than the other group. It might be because red is connected with risk and failure, the researcher hypothesized.

On the other hand, cool hues tend to have opposing relaxing effects; they encourage peace and relaxation. People tend to be more explorative and their creative processes flow more easily when they are at ease. Even lowering the crime rate is possible with the installation of blue lighting in streets or train stations. People may feel calmed by cool hues like violet, green, and blue [48]. Blue, green, and purple medications are said to have calming or even numbing effects, whereas red, yellow, and orange pills are thought to have stimulating effects. A study looks into how color affects the placebo effect. Despite receiving placebos, every participant thought they had been given stimulants. The warm-colored pills were given to one group, and the cool-colored ones to the other. The results demonstrated that recipients of warm-colored pills experienced a stronger placebo effect than those of cool-colored pills [49].

Also, according to some research, when people's income levels rise above the normal level of living, they start to buy plants for their homes and gardens, engage in nature-based activities and hobbies, and buy houses with gardens for themselves, which are

well-known indicators that people get various benefits from being in touch with nature [50]. Also, research on the positive effects of nature on human psychology has shown an increasing development in the last 30 years. Considered one of the first such studies, a study investigated the psychological benefits that people derive from their home gardens.

Studies in this field have shown that watching nature can positively affect people's physical health as well. The most controversial among them is a study conducted by Ulrich (1984) in a hospital in Pennsylvania on patients who had undergone gallbladder surgery. Patients in the same post-operative recovery period, who stayed in a room with windows facing the forest, requested less pain relief, showed more positive behavior towards the surgery they had recovered more quickly, and were discharged than the patients who stayed in a room with windows-facing the hospital wall. The reason for this is the endorphin hormone, which is released in the human body when people meet the green fields and nature. As mentioned in the previous chapters, endorphins are the natural pain-relieving hormone of humans, and in such cases, it reduce the pain felt. Another study (Verderber, 1986) among patients who suffered severe disability as a result of accidents or certain illnesses also showed that such patients preferred landscapes containing natural areas or trees over others. Heerwagen (1990) conducted a study on the anxiety and restlessness of patients waiting for their turn in a dental clinic and measured by various physiological methods that patients on the day when a large natural landscape painting was hung on the opposite wall in the waiting room were less stressed than the patients on the day when the wall was empty. The reason for this is that the green color and natural images help people to release dopamine and serotonin in their bodies. It can be said that people who are exposed to

green color and nature are less stressed and happier, as can be understood from the experiments as well.

Lastly, some experts have suggested that bright colors should be worn in the winter, especially in northern states where everything is white, gray, or black since they believe that they might uplift people's spirits and act as "emotional vitamins".

It is without dispute that color has a positive impact on attention span. Additionally, studies demonstrate that the use of color in the classroom increases reading comprehension by 73%, readership by 40%, and total learning by 55-78%. Clinical interventions for dyslexic students have been shown to be successful in lowering reading difficulties. Students with autism have benefited from the usage of colors. When compared to autistic children who did not employ the colored overlay, autistic pupils who did exhibited a 35% increase in reading speed. Additionally, studies have looked into how color combinations affect memory. More attention and better visibility are drawn by stronger color contrast, which affects memory retention.

In addition to all of these, the colors employed in the places have a significant impact on how people see things as well as psychological impacts. For instance, lighter and cooler hues give the impression that the area is larger. Darker hues give them a more closed-off and diminutive appearance. The use of colors in a space alters the perspective, giving the impression that the room is taller, longer, or wider, or that a particular piece is being highlighted. It is possible to stretch, widen, narrow, shorten, shorten the walls, and/or highlight a specific object in space by employing contrast colors. Contrast colors can also be used to enlarge, condense, lower the ceiling, stretch, widen, and/or narrow a space (Figure 12) [51].

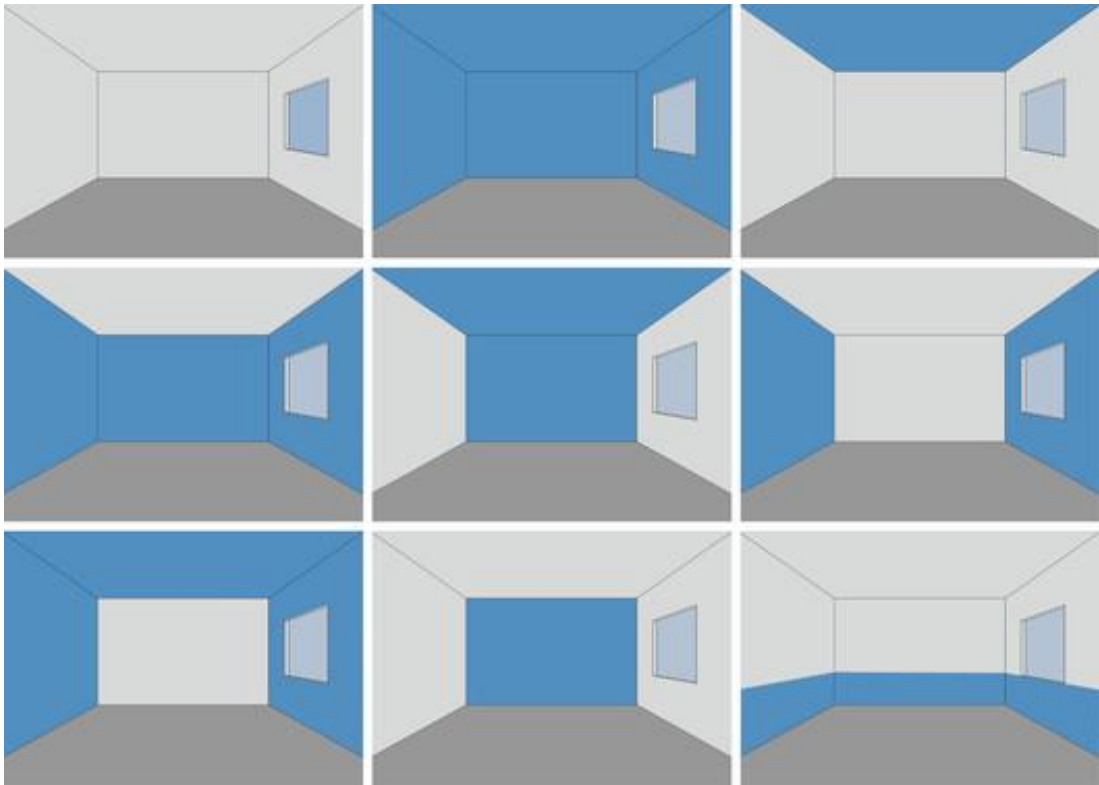


Figure 12: Color effects in space [51]

### 3.2.2 Lighting

Understanding how individuals react to light cognitively and emotionally is made easier by lighting psychology. Again, similar to how colors create more than just visual effects, light also has biological and psychological consequences that can have an effect on people's health and wellness. When light affects people biologically, it can enhance or impair our sleep, cognition, and general welfare. It can elevate mood and balance circadian rhythms, which makes it easier to sleep better and longer at night. Light has been shown to improve cognitive performance, such as reaction time and activation, while also lowering depression levels [52]. While there are many psychological aspects that might affect how people see light, it's crucial to take into account the position of light as well as its brightness, color, and saturation. The Illuminating Engineering Society, which lists many lighting effects and their potential

effects on space, has created the table below (Table 4). According to the research, intense direct lighting from above creates a tense space, while lower and warm-colored lightings give a relaxed atmosphere. For workspaces, cooler tones and bright lights are beneficial. For the spaces that require spaciousness, again bright colors on walls or ceilings should be preferred. On the other hand, a low light level at the activity space with little perimeter lighting and dark areas in the rest of the space gives privacy or intimacy to the atmosphere of the space.

First, where the lights are placed in a space affects how it functions. Lighting around a room's edges might give the impression that it is larger. A tense atmosphere can be evoked by central, bright light. An aura of constraint and formality can be created by placing lighting above eye level. On the other hand, lighting that is lower than eye level can evoke a sense of personal significance and foster a cozier environment.

The primary use of light, seeing things, is caused by another element called brightness. The degree to which a light fulfills this purpose also affects people psychologically. Robert Dawis, a cognitive psychologist with a doctorate, claims that strong light "helps to make sense of an environment... making it a more pleasant space." People are less likely to enjoy a space if there is insufficient lighting to understand what is going on in it.

Table 4: Lighting Effects and their potential effects [52]

PSYCHOLOGICAL IMPACT	LIGHTING EFFECT
Tense	Intense direct light from above.
Relaxed	Lower overhead lighting with some lighting at room perimeter, warm color tones.
Work/Visual Clarity	Bright light on workplane with less light at the perimeter, wall lighting, cooler color tones.
Spaciousness	Bright light with lighting on walls and possibly ceiling.
Privacy/Intimacy	Low light level at activity space with a little perimeter lighting and dark areas in rest of space.

Content retrieved from IES Light Logic ([www.ieslightlogic.com](http://www.ieslightlogic.com))

According to an article in Electrical Contractor magazine, a light's relative brightness in comparison to the surrounding light might have psychological effects on people. For instance, at a grocery store, the relative brightness of racks holding snacks in the checkout line can call attention to them. Additionally, brightness has a significant impact on eating habits. People seek unhealthy meals more because they feel less aware of low light. According to one study, diners at restaurants with poor lighting ordered 39% more calories than diners in restaurants with better lighting. On the other hand, other research has demonstrated that brighter light can amplify emotions whereas low light maintains them rather than removing them. As a result, individuals may be better able to reason under difficult lighting conditions and find it simpler to reach a consensus with others [53]. Extreme brightness, however, is not necessarily a good thing; it may easily become overwhelming and obscure the subtleties of the created rooms. Another study discovered that people perceive their emotions as being

more intense in relation to light intensity. For instance, even if the temperature hasn't been raised, people actually feel warmer in intense lights. It is therefore perfect for gathering areas like the living room or kitchen.

The color or hue of the light also contributes to how lighting impacts mood. Cool, blueish light or daylight is a good option for brainstorming rooms since it increases alertness and productivity, according to a UNC Kenan-Flagler Business School essay on office lighting. Inviting white lighting is ideal for conference rooms. It is recommended for break rooms to have warm, reddish-to-yellowish lighting since it promotes relaxation. On the other hand, blue light, for instance, might boost daytime productivity. However, because blue light is typically emitted by electronic devices, researchers have recently studied its effects. According to a Harvard Health letter, "Blue wavelengths, which are beneficial during daylight hours because they boost attention, reaction times, and mood, seem to be the most disruptive at night." Decide on blue light or daylight when selecting illumination for a daytime workspace. While muted colors might depress emotions, more vivid hues can have an amplifying impact. As a result, lighting can have an impact on how people perceive color. Bright light "intensifies" some hues while dark light "washes away" others. Color fatigue can result from improper or excessive color use. Some cones in the eye may become more sensitive than others when highly contrasting colors are followed by one another on the retina [54].

### **3.3 Olfactory Perception and Psychology**

Olfactory perception is a process that begins in the nose with olfactory sensory neuron stimulation and ends in higher cerebral centers that, when activated, cause people to become conscious of an odor. While odor detection or discrimination tasks are

typically utilized in animal research, verbal reports are typically used to confirm this awareness in humans. The ability to sense a smell is known as smell perception, whereas olfaction is the broad term for perceiving odor molecules. The smell is a perceptual skill that depends on the inner biological workings of humans or other creatures and is not something that originates from odors alone. Because of this, the way people perceive smells might alter over time depending on a variety of things. For instance, the more people are exposed to a certain scent, the more sensitive and quicker they get at recognizing it they become.

People can detect the smell or quality of the air through their breath. Human respiratory rates typically fall between 10 and 20 breaths per minute. The range is reduced to 4–10 breaths per minute with slow breathing. Around the world, yoga and meditation practices have long used a variety of slower and regulated breathing techniques, including nose breathing, abdominal breathing, and vocalized or chanting breathing.

The process and consequences of breath control and other breathing techniques, however, have largely been disregarded by scientific researchers and medical practitioners until recent decades. Through the vagus nerve, which travels from the brain to the abdomen and triggers a relaxation response that calms individuals down, deep, slow breathing has a direct impact on brain function. Because of this, whether someone is experiencing worry, rage, or stress, they can use their breath to maintain or restore a sense of serenity, reduce their heartbeat, and maintain their blood pressure. To better prevent and treat mental illnesses, it is crucial to comprehend how breathing affects the brain and, by extension, mood, emotions, and behavior [55]. A very significant increase in the incidence of mood disorders including anxiety and sadness is linked to difficulty breathing. Today, it is understood that breathing, respiratory

disease, and psychological illnesses are all interconnected. To better prevent and treat mental illnesses, it is crucial to comprehend how breathing affects the brain and, by extension, mood, emotions, and behavior.

The diaphragm is the body's strongest muscle from a psychological standpoint and functions as a second heart during deep breathing. The diaphragm relaxes downward during inspiration, generating a vacuum and allowing air to flow into the lungs. When one exhales, the diaphragm contracts upward, pushing air from the lungs outward. Every inhalation energizes and stimulates the sympathetic branch of the autonomic nervous system, and every exhalation relaxes and stimulates the pneumogastric nervous system that runs along the spinal cord. Obviously, something so spinal cord-related has a big impact on how people think. Even some scientists in this field agree that when people are anxious or stressed, breathing gets shallower and faster, which can disturb the equilibrium of oxygen and carbon dioxide and lead to an increase in feelings of fear, panic, and anxiety. Similar to depression, you could feel exhausted, broken, and depressed, and this interferes with your ability to breathe. The smell and the air quality in the place are the two main elements influencing this psychology in spatial formations through breathing [56].

### **3.3.1 Air Quality**

According to a study published in *Environmental Health Perspectives*, children of mothers who were exposed to higher levels of NO<sub>2</sub> during pregnancy, particularly in the first and second trimesters, were more likely to have children who had behavioral issues. At the same time, evidence suggests that children's exposure to pollution is a statistically significant predictor of their academic performance and has an impact on both their cognitive and mental health. The effects of poor air quality on children's

academic performance have been well documented. According to studies, schools in locations with greater air pollution levels also had lower attendance rates and a larger percentage of kids who failed to satisfy the requirements for state-mandated academic testing. Children exposed to greater levels of air pollution are considerably more likely to have brain inflammation and damaged prefrontal cortex, according to a 2012 study comparing two cities in Mexico. In addition to these structural variations, the youngsters in the more polluted areas also performed worse on tests of memory, cognition, and IQ [57].

High levels of air pollution exposure throughout childhood can have detrimental effects on adult mental health, including anxiety, depression, and neurodegenerative illnesses. According to research, prolonged exposure to high particulate matter levels might cause serious short-term cognitive impairments. According to a 2019 study, those who are exposed to more polluted air indoors or outdoors are more likely to develop mental illnesses such as depression, schizophrenia, bipolar disorder, and personality disorders [58].

There could be several causes for this air pollution. In essence, it is split into two categories: indoor pollution and outside pollution. Particulate matter, carbon monoxide, ozone, nitrogen dioxide, and sulfur dioxide are pollutants of great public health concern. Indoor and outdoor air pollution are significant contributors to morbidity and mortality because they cause respiratory and other illnesses.

### **3.3.2 Smell**

The olfactory bulb, a structure in the front of the brain, processes smell before sending data to other regions of the body's central nervous system. The limbic system, which includes the amygdala and the hippocampus and is connected to emotion and memory,

is directly reached by odors. The ability of smell to influence how customers interact with a brand, a product, or a location is very powerful nowadays.

It is well known that various aromas affect people differently. One particularly well-known example is lavender. It can aid with relaxation and lessen the physical effects of anxiety when used appropriately. In fact, lavender is frequently used as a significant element in the formulation of sleep-related goods. A well-known olfactory relaxant is lavender. But as it turns out, there are a variety of smells that can have advantageous effects on the body. Jasmine promotes a positive outlook and helps to increase energy, ginger fights fatigue and can even help to lessen pain, lemongrass reduces stress and can lessen the effects of anxiety, and peppermint helps to become laser-focused. Rosemary helps heighten memory and alertness. Vetiver boosts oxygenation within the cells and helps increase concentration. Coffee is a great anchor scent to wake someone up [59]. It is hardly surprising then that smell loss has been linked with depression, loneliness, and eating disorders.

All these smells and aromas have great meanings in spaces as well. Therefore, if smells and aromas are used in accordance with the function of every space, people's perception of space can be more understandable. As a result of some research, it has been proven that the places where scent is used are processed in a more understandable way, while the ones without scent lose some of their meaning and make their spatial value feel less than it actually is [60].

### **3.4 Auditory Perception and Psychology**

The capacity to recognize and understand information that enters the ears via sound frequency waves delivered through the atmosphere or by other sources is known as

auditory perception. For the development of auditory perception, the environment must have both air and sounds. Additionally, the brain must evaluate the sound's qualities and features, including intensity, tone, timbre, and duration, in order for auditory perception to take place. The volume's intensity tells us if it is high or low. Tone describes the pitch of the sound. Timbre, often known as the "color" of sounds, is what enables us to discern and distinguish different voices, instruments, and noises. Last but not least, duration refers to how long the sound vibration lasts [61].

The brain receives the impulses from the cochlea through the auditory nerve fibers. Numerous relay stations in the brain take in the information and decode it to produce an experience or conscious perception. The cochlea's ability to operate can change thanks to the brain. For instance, even if our hearing is being stimulated by a variety of sources that are frequently louder, people may focus on a friendly discussion in the background noise of a cocktail party. However, the mind has requested that people give the data from the intriguing dialogue priority.

The brain processes sounds, which are converted in the ear into neural signals, at a variety of levels: a reflex, where the arrival of the message causes us to jump or turn our heads; the auditory cortex, where the sound is perceived; other brain regions, which enable the perception to become conscious; recognize the sound by comparing it to those that have previously been memorized; and decide on an appropriate voluntary response [62].

Naturally, hearing these sounds has certain psychological repercussions on the brain. Noise and ambient music are two categories of auditory elements that can have an impact on psychological health.

### **3.4.1 Noise**

People are almost always surrounded by noise, whether it comes from a natural source like a bird song or from a human activity like driving. However, excessive noise might have a negative effect on people's health. Unwanted sound and noise pollution, when compared to other types of pollution, can have a variety of negative consequences on mental health. Even while you are asleep, the brain is constantly listening for symptoms of trouble. As a result, constant or loud noise might cause worry or anxiety. A person becomes more sensitive to stress as they are exposed to noise pollution on a regular basis.

Noise pollution can make people agitated, tense, frustrated, or angry. Noise pollution can impair a child's hearing at any stage of development, including fetus, infancy, and adolescence, according to a study published in *The American Journal of Pediatrics*. Additionally, children may find it difficult to learn if there is excessive or unwelcome noise at home or school. Additionally, they might have more issues with cognitive performance, speech and communication development, and focus [63].

### **3.4.2 Music**

Blood flow to the parts of the brain that produce and regulate emotions is increased when you listen to music. When people hear music, their limbic system, which is involved in processing emotions and managing memory, activates. People may get goosebumps when they hear a particularly moving piece of music because of dopamine, a neurotransmitter that promotes feelings of happiness and well-being. It's interesting to note that people's moods can be affected by music even if they can recognize or mimic the sounds or rhythms. Science has documented numerous instances of patients with brain injuries who were unable to distinguish melodies but

could still recognize the emotions that music evoked. A multitude of different things, such as pitch, timbre, rhythm, dynamism, and others, are crucial to music. "Integrate the sequentially arranged sounds into a cohesive musical sense" is what the brain needs to do in order for it to decode music, according to the Journal of Biology research.

There is proof that suggests music listening enhances brain function and increases the brain's capacity for adaptation. According to a study published in the Scientific Journal Brain, adults who had a stroke and listened to music every day showed significantly greater improvements in verbal memory and cognition after two months compared to stroke survivors who listened to audiobooks and those who didn't listen to either music or books on a regular basis [64].

After hearing ten of their favorite songs, people can accurately assess a person's level of extraversion, inventiveness, and open-mindedness [65]. According to one study, people define themselves through music and utilize it as a communication tool with others. This explains why it might be difficult for people to defend their musical preferences because doing so feels like a criticism of oneself. The findings of a study by psychologists Sam Gosling and Jason Rentfrow point to the surprising accuracy with which one's personality can be predicted by the music one listens to. Extroverts, for instance, enjoyed the study's powerful bass lines, whereas people who prefer more complex genres, like jazz and classical music, are more intelligent and creative [66]. Another illustration of how music affects psychology is the speed at which people recover from stressful events after they have been listening to music. Cortisol is the human stress hormone, and people are more stressed when their cortisol levels are higher. Symphonic music, regardless of the listener's musical preferences, has been shown in trials to lower cortisol levels. Another study found that, particularly in those

who have a propensity for ruminating or social withdrawal, listening to nostalgic, depressing music may make depressive symptoms worse. Even for a number of illnesses like heart disease, depression, autism, and Alzheimer's, there is a therapy called "music therapy" that is supported by research. It can help with self-esteem, coping, stress reduction, blood pressure, and memory.

In conclusion, it is feasible to state that the use of music in constructed settings not only helps individuals recover more quickly from physical illnesses but also improves their mood and makes them feel less nervous and unhappy.

### **3.5 Tactile Perception and Psychology**

A flurry of studies in recent years has revealed amazing advantages of touch for both physical and emotional well-being. According to this research, touch is actually essential for human connection, communication, and health. According to embodied cognition, your body and mind function as a supercomputer that processes everything and causes all of your reactions. Because of this, individuals find the texture of beds to be comforting when they are fatigued or happy to slip into cool water when they are hot.

A particularly intrepid team of researchers set out to determine the feelings that were elicited by no fewer than 21 distinct textures, including leather, velvet, steel wool, silk, slime, and velvet. In general, pleasant emotional reactions were triggered by soft and smooth textures while unpleasant emotional reactions were produced by rough or harsh textures.

The perceived visual texture of the eyes can elicit strong reactions. Textures and human psychology have long been interwoven. Every texture has a relationship to a

person's personality, mind, or mood. Additionally, people use particular fabrics to meet distinct emotional requirements. For instance, when someone needs some emotional reassurance, they gravitate toward smooth and soft textures. While rougher, tougher textures represent strength and masculinity. These surfaces are robust and draw their properties from natural materials.

The texture that is associated with pleasure is smooth. Fur, silk, and velvet all fall under the heading of smooth textures. On the other hand, comfortable fabrics like cotton and linen are typically those with gentle textures. There are calming and soothing textures. They may not be idealistically opulent, but they are practical and create a feeling of security and tranquility. Although there is a very fine border between smooth and soft textures, they have different emotions. Rough textures are frequently mistakenly thought to be indicative of an aggressive disposition. Contrary to popular belief, rough textures are warm and earthy. The textures borrow heavily from the surrounding natural textures that currently exist. These textures lack the fragility of smooth surfaces, which is another sign of endurance and durability [67]. Pattern or shape are two other terms that can be used to describe tactile sense in addition to texture. Similar to textures, soft patterns, and shapes give people a more cozy and tranquil setting, but hard, geometric designs give people a more formal and serious surroundings feeling. Recent technology advancements have made it so that the patterns of products, the forms of facade cladding, and the textures and shapes felt in every touched region have a significant psychological impact.

### **3.6 Gustatory Perception and Psychology**

Researchers Corinna Noel and Robin Dando have found that people are more receptive to the sweetness of food when they are feeling well [68]. Negative emotions have a

tendency to make people more sensitive to sour flavors. According to scientists, this is caused by an increase in the brain's release of the neurotransmitter serotonin while people are feeling good feelings. The taste of a meal might vary depending on a number of factors. These dependencies include the food's plating, the environment's acoustics and music, and the color of the meal.

### **3.6.1 Colors and Taste**

People's taste buds make some judgments based on an object's color before they eat or drink. Ndom, Elegbeleye, and Ademoroti's study found that, despite there being no correlation between participants' estimations and the drink's flavor, the color of the drink had a significant impact. Participants who stated that a red drink was sweet and a green drink was sour claimed that red reminded them of berries and green lime. This viewpoint contends that people's palates are influenced by the hues of the meals and beverages they consume. In actuality, colorless Coke and Heinz ketchup failed to catch on when they initially appeared on the market because consumers complained that the flavors were off. The ingredient list, however, has never changed [69].

### **3.6.2 Sounds and Taste**

Restaurants are starting to use sound as a technique to improve the flavor of the food being served. The Fat Duck restaurant in Berkshire provides one of the most well-known illustrations of this. The proprietor offers a unique cuisine called Sound of the Sea where fish is served while ocean sounds are played in the background. Many customers felt that this improved the dish's flavor and overall experience.

There are three basic theories, according to Dr. Qian Janice Wang, whose research examines how aural inputs interact with flavor. The first one is known as "expectation theory," which states that people are evolutionarily predisposed to form predictions

about meals before consumption. According to the second idea, "attention capture," when meals contain complex flavors, this may lead to consumers paying more attention to one taste or flavor than others. Finally, the "halo effect" or "emotion mediation" of sound and music might cause people to experience particular feelings that may then influence how they perceive the food. This might explain why many consider foods to be sweeter when enjoying their favorite music [70].

Even so, the investigation on this subject yielded an intriguing discovery. Researchers have shown that a particular sound can alter a person's desire to eat. They dubbed this hypothesis "Sonic Seasoning." Low-frequency noises are supposed to impart bitterness to food, while higher frequencies are said to contribute sweetness, adding levels of up to 15% of sweet, salty, sour, and spicy tastes to the foods. It can be compared to adding music to food rather than salt or sugar, and it's a crucial invention for those who are concerned about their meals.

### **3.6.3 Plating and Taste**

The presentation of the food on the dish also has an impact on how it tastes. According to a study by Peter Stewart and Erica Goss, round white plates increase people's perception of the sweetness of the food by 20% and the depth of flavor by 30%. Some theories suggest that this occurrence arises because the food served on a white dish seems to have a stronger flavor since the colors are more vibrant [71].

In the end, the brain is doing a lot more than just enjoying that piece of cake. People's emotions, as well as the color of the food, the noise around them, and a number of other elements, all have an impact on how much they enjoy the food they are tasting.

## Chapter 4

# NEURO-ARCHITECTURE; WELL-BEING AND SPATIAL PERCEPTION

The connection between human psychology, neuroscience, and the built environment is a relationship that cannot be ignored. This connection has been revealed with the help of different disciplines since ancient times, but with the influence of modernism, it increased its importance and began to be examined with different methods thanks to developing technologies. In this branch of research, especially recently, the contribution of neuroscience to architecture and human psychology has been examined through experiments and deepened the knowledge and experience on this subject.

A new topic known as "neuro-architecture" focuses on how the built environment affects human behavior in the brain. It blends architecture, psychology, and neuroscience. Others define the topic of neuro-architecture as one in which neuroscientists and architects work together to investigate how people interact with their surroundings scientifically. The primary goal of neuro-architecture is to investigate how the architectural environment affects the neurological system. Neuroscience can enhance the design process, design tactics, and inform rules that eventually improve human health and well-being in the future based on our growing understanding of how the brain perceives its environment [72].

According to another source, the field of ‘neuro-architecture’ focuses on creating functional environments by using neuroscience to investigate the connection between human health and architecture. It investigates how architectural components affect people’s mental and physical wellness. It is based on the idea that human-added artificial features to an environment have a big impact on how the brain and the nervous system work. It combines three disciplines; architecture, psychology, and neurology [73].

There is research on how the body and brain respond to the built environment, especially in terms of how the brain responds to design. In contrast to traditional design, neuro-architecture is more concerned with people and creating environments that promote happiness. Although the field of neuro-architecture was established in the 1950s, anyone can claim that it has existed ever since the beginning of time. The objective would still be the same even if the name didn’t exist. Primitive humans tended to select specific ecosystems in which to reside as a strategy for survival. In light of this, the prevailing theory is valid; people have always had psychological reactions to spaces, as shown by the habitat choice of the setting that gave early humans a sense of security [74]. People are made to feel relaxed, safe, productive and a host of other positive emotions thanks to neuro-architecture, which also improves the built environment. According to The Academy of Neuroscience for Architecture in San Diego, research into how architecture affects user behavior is based on different criteria. For instance, a well-balanced temperature creates a comfortable environment. As a result of the human brain’s extreme sensitivity to rapid temperature changes, residents’s mental and emotional health may suffer. An intense light helps activate human brains and reduce stress. On the other side, inadequate lighting alters the

circadian rhythms and has a negative impact on mood and activity levels. A biophilic or ecological design's use of natural materials and green spaces has a favorable impact on people's behaviors. Or, another example, not every building takes scents into consideration. However, the correct aroma, such as a natural scent, can improve the environment and atmosphere. And interestingly, instead of having angular, sharp edges, round curves assist the brain to relax [75].

Neuro-architecture does not adhere to a predetermined process. The method depends on the kind of space, the client's needs, and the building context. Depending on the need, the color, light, scale, materials, landscaping, and acoustics change. The working of the brain toward different patterns is revealed by neuroscience to be influenced by heredity, culture, and the individual. As a result, different persons can be affected differently by the same environment. Therefore, it is necessary to comprehend the possible users who can make good use of the environment and result in the successful implementations of neuro-architecture.

An essay by Emily Ethens titled "Building Around the Mind" in the most recent issue of Scientific American Mind explores many architectural aspects that affect the human mind. The 2007 study "Building Around the Mind" details how an individual's processing of information was shown to be influenced by the room's ceiling. As found, a room's lower ceiling encourages inhabitants to pay more attention to details. Higher ceilings encouraged residents to think more abstractly and creatively.

Additionally, recent research has demonstrated that the process can work in both directions or at least in a bidirectional manner, allowing an external factor (such as the structure that shelters us) to also elicit contemplative states and alter brain activity.

Researchers recently investigated whether design might encourage meditation in a study. These researchers were interested in determining whether environments such as museums, church, or libraries had a similar effect on brain activity to meditation. They assembled a uniform group of 12 architects who had never meditated before to conduct this study. Their brain activity was scanned and mapped as they were given pictures of various structures. Six of the 12 architectural spaces they were given, were photographs of commonplace structures like homes, school, offices, while the remaining six were pictures of ‘‘contemplative’’ structures including the Salk Institute, Notre Dame du Haute, the Alhambra, Chartres Cathedral, the Roman Pantheon and Chartres Cathedral. According to the findings, contemplative environments stimulated the brain’s cortical regions that integrate emotions and motor signals as well as areas connected to absence of judgement and concrete representation. The findings also indicated that exposure to these environments decreased anxiety and the propensity to become distracted. Although the findings did not demonstrate that ‘‘contemplative’’ architecture had exactly the same effects on the brain as meditation, they did show that it had good impacts, similar to those they study’s participants reported when they meditated. This form of architecture is more directly linked to significant aesthetic experiences and psychosomatic emotions, which was one of the key differences [76].

According to one study conducted by Tülay Karakaş and Dilek Yıldız, the information obtained from this research was compared by classifying the concepts within each group as overlapping, comparable, and distinct. First, comparison suggests that the concepts that were established and used in experimental investigations at the nexus of neurology and architecture were those that were already familiar from environment and behavior studies (Table 5). However, neither theoretical nor experimental

investigations at the intersection addressed a number of key ideas in the field of environment and behavior, such as privacy, territoriality, crowding, personalization, sense of place, place identity, and sense of attachment. Therefore, these ideas could not have been applied to neurology at this time [77].

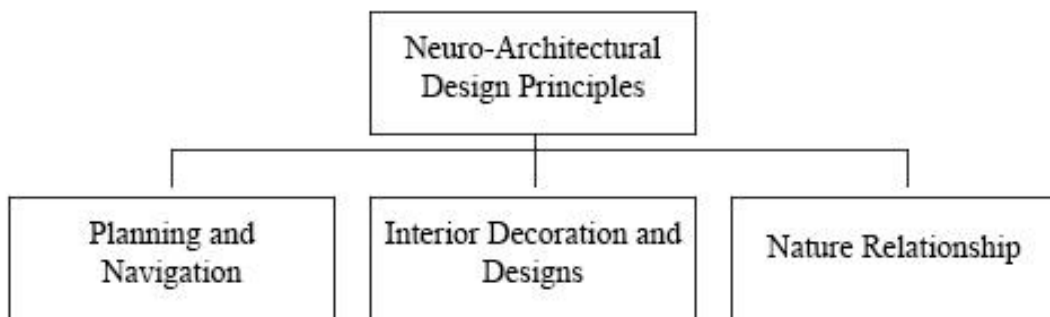
Table 5: Outcomes extracted from the experimental articles through neuro-science [77].

Emerging and developing concepts	Human experience	Built environment features	Measurement techniques	References
Restorative and stress reduction effects of environments	Well-being, restorativeness, and stress	Natural environment and built environment without nature, building-integrated vegetation, stimulus in interior spaces (vegetation, music, and visual features), bed positions, and orientations	fMRI, EEG, VR, EDA, HRV, questionnaire, self-report, and post-test measurements	Martínez-Soto et al. (2013); Hekmatmanesh et al. (2019); Higuera-Trujillo et al. (2019)
Aesthetic judgment/ appreciation	Pleasure, familiarity, novelty, comfort, and pleasantness	Arrangements of furniture, windows, and doors, visual complexity, architectural decorum, typicality, and ambiances of interior spaces	EEG, VR, aesthetic judgment tasks, and rankings	Grima Murcia et al. (2019); Vannucci et al. (2014); Vecchiato et al. (2015)
Pedestrian experience, navigation, and Wayfinding	Mediation, attention, anxiety, displeasure, positive and negative emotions, intense and mild, pleasant and unpleasant, directional behavior, familiarity, and fear	Urban characteristics of a place (edges, patterns, shapes, and narrative), urban spaces and forms (building shapes, textures, isovist parameters, visual entropy, visual fractals), physical characteristics of routes, and ceiling height	EEG, VR, GIS, GPS, body sensors, self-report, and video recording	Li et al. (2016); Erkan (2018)
Visual engagement, visual attention, and imageability	Visual attention, avoidant behavior, conscious and unconscious attention, efficient, pretty, safe, pleasant, and interesting	Spatial characteristics of urban streets (street edges, ground, sky, existence of people and objects, and adjacent realms), characteristics of civic monuments (front facades), and architectural space geometry (square, round, sharp, and curvy)	EEG, VR Eye tracker, MoBI, video recording, questionnaire, self-report, and scorecards	Simpson et al. (2019); Sussman and Ward (2019); Shemesh et al. (2017); Banaei et al. (2017); Holander et al. (2019)
Phenomenological experiences, experiential intensity, positive/negative user experience, multisensory experience, and natural experience of architectural spaces	Relaxation, excitement, engagement, stress, focus, interest, attention, appreciation, peace, beauty, connectedness, anxiety, pleasure, motivation, pleasant, and frustration	Characteristics of religious spaces, mosques, and spirituality of the built environment, ordinary and contemplative architectures, architectural design features (presence and size of windows, spatial alignment, contours of objects, natural daylight, exposure to nature, density, height of ceiling, flexibility in isolation/socialization, openness of space, color, artificial lighting, visual cue and landmark, shape layout, texture material,	fMRI, EEG, VR, EDA, HRV, questionnaire, self-report, post-test measurements, crowdsourcing, and semantic differential scale	Vijayan and Embi (2019); Bermudez et al. (2017); Ergan et al. (2018); Higuera-Trujillo et al. (2019)

## 4.1 Neuro-Architectural Design Principles

The best way to establish a method for integrating neuroscience into the spaces is to first understand and explore the research that neuroscience has produced in relation to interior space, as well as the case studies where these findings have been used. The identification of the numerous sensations that must be triggered inside an interior space is the first step in the design process. Understanding the different interior spaces and their key features is also essential, as well as using neuro-design principles meant to inspire creativity or a sense of enlightenment (Table 6) [78].

Table 6: Neuro-Architectural Design Principles [78]



Look at the fundamental behaviors, which include the use of the five senses to perceive the environment, in order to start understanding the relationship between neurology and interior space. It is undeniable that perception involves spatial characteristics like color, light, texture, smell, and sound as well as spatial navigation, where the human brain records sensations through sight, sound, and touch, and interior design components like form, color, materials, natural light, and nature that affect the human psyche. Neuroscience investigates how the physical environment affects cognition, problem-solving skills, and emotions. By grasping these ideas, interior designers may create environments that support spatial orientation while simultaneously strengthening cognitive skills and reducing detrimental emotional and motivational

consequences. The neurobiology of human perception has an impact on a number of interior design ideas. By categorizing these ideas, the neural interior design process is made clearer, and the designer is able to modify the thoughts for various types of places. Planning and navigation include layout visibility, spatial connectivity, volume of space, and furniture planning. Enriched interior spaces are related to the phenomena that people experience with their five sense organs. And lastly, the nature feature is the principles that are related to connectivity with the outdoor nature or indoor nature features.

"Neuro-architecture" is the term used to describe interior and exterior design that is intended to affect and change human physiological and psychological responses. Most architects and interior designers use some type of neuroscience to create places with human emotional responses and well-being in mind. Some of the components of the neuro-architectural design process include spatial organization, lighting, acoustics, color, atmosphere, scale, transparency, and access to nature [79]. This thesis asserts that case studies that were intentionally made with this goal in mind were designed in order to take advantage of sensory biases and generate awe.

#### **4.1.1 Neuro-Architecture in Healthcare Spaces**

It's not surprising that neuroarchitecture, along with evidence-based design and therapeutic architecture, is regularly established as a priority over aesthetics given the vital care and urgency required in healthcare environments. Integrating exterior views or therapeutic gardens has been a design strategy since at least Ancient Greece [80]. One study showed that patients with views of nature recovered more quickly from surgery and needed less pain medication than those who had a view of a brick wall [81]. Natural light and window orientation in healthcare facilities have been

linked to reduced length of stay, quicker post-operative recovery, more effective pain management, and increased employee morale. When designing for senior and dementia care, navigation and orientation can be aided by color in signage and zoning, which is an important factor to take into account [82].

The majority of doctors agree that a proper ratio of natural and artificial light can have a good impact on some conditions in a hospital setting. Numerous research have been conducted on the impact of light on Alzheimer's patients in response to this issue and identify factors to take into account when deciding on the quality of lighting, including glare, flicker-free illumination, uniformity in ambient lighting, orientation of the light to the visual task, color rendition and temperature, and a balance between artificial and natural light. These are important factors to consider in creating a healing environment in a healthcare building.

Researchers have established that seasonal affective disorder is a mental illness with a definite etiology that includes the onset of a new season and a lack of daylight. Additionally, researchers found that either one hour of daylight or a half-hour of white light with a brightness of 2800 lx improves the clinical condition of patients with seasonal affective disorder [83].

#### **4.1.2 Neuro-Architecture in Work Spaces**

In order to influence employee well-being, performance, retention, and enjoyment at work, neuro-architectural techniques are becoming more and more popular in the workplace. According to one study, office workers who were exposed to more natural light had better sleep overall, greater physical activity, and a longer sleep duration than those who were exposed to less light. High noise levels in offices, particularly those with open floor plans, can interfere with focus and productivity. Zoning and other

office acoustics strategies, as well as architectural elements like acoustic solutions, contribute to comfort by reducing noise. In large part because of the connections between mindfulness training and performance, many organizations (particularly startups and tech corporations) are constructing meditation rooms [84].

#### **4.1.3 Neuro-Architecture in Educational Spaces**

Of course, the same approaches are applied to educational spaces, especially for children. The architecture of the rooms that children occupy has a significant impact on their healthy growth and development, according to recent studies. The Academy of Neuroscience for Architecture was the first to use neuroarchitecture in the design of educational spaces in 2005. It concentrated on how the physical environment affects the concentration, attention, and cognition processes in the brain.

The design of educational buildings had a significant impact on the specific qualities that the academy researched. By examining different lobes of the brain, they reached some conclusions. The occipital and parietal regions of the brain which are related to focus, attention, and cognition are directly proportional to natural light exposure. The prefrontal lobe which is related to rational reasoning is inversely proportional to stress level, which means that as the stress levels of children in the educational environment increase, their capacity to engage in rational reasoning decreases [85].

On the other hand, color and texture also have a significant impact on student learning. Expected learning outcomes have been linked to specific colors and textures. Additionally, color-zone difference can make navigation easier. The benefits of daylighting are numerous. Kids in classrooms with natural light made 20 percent more improvement on math tests and 26 percent more advance on reading tests, according to a research containing data on over 21 000 kids. Students' ability to hear, learn, and

think, as well as their general academic performance, are all impacted by the degree of noise in the classroom. For every 10dB increase in noise above 41dB that young children experience, they lose 5.5 points on national standardised tests, according to one study that examines acoustics in education [86].

## **4.2 Neuro-Architecture Case Studies**

This field first emerged in the 1980s with the advent of evidence-based design and environmental psychology, respectively. The Academy of Neuroscience for Architecture was established in San Diego, USA, in 2003, and this marked the start of a new field known as neuroarchitecture.

Humans have always responded physiologically to places because they performed what is known as "habitat selection," a challenge that was rife with survival dangers. Because neuroscientists can now evaluate these behaviors to advance our comprehension both metaphorically and literally, neuroarchitecture is at the forefront of design [87].

### **4.2.1 Healing Places in Ancient Times**

Aalto, Frank Lloyd Wright, and other twentieth-century architects were influenced by the ancient Greeks' conviction in the healing potential of certain locations. Asclepieions, named after the Greek deity of medicine Asclepius, were healing temples in ancient Greece. People in need of medical care travelled great distances to visit a clinic. The medical therapies, baths, dietary regimens, and rituals performed there were supposed to benefit from the temples' innate healing capabilities. These shrines were frequently built in forested areas with surrounding springs. Stones or a built enclosure called a temenos served as the boundary between the sacred ground and the surrounding areas. Buildings were typically elevated slightly off the ground

and faced east, or toward the rising sun. Complex heated pools were built to act as saunas for medicinal purposes. In fact, such centers of healing were revered by ancient societies all across the world. The ancient Indian discipline of architecture known as vastu shastra has design guidelines that are thought to promote health. Writings cover subjects including the ideal orientation for one's body while sleeping and the best location for their front door.

The first examples of organic architecture are also found in these works, along with instructions on how cities and kingdoms should coexist peacefully with gardens and water features. It was thought that being close to gardens was good for both one's physical and mental wellbeing. In vastu shastra, the sun also played a significant role. The sun rises in the northeast and sends forth its first rays across the south before setting in the west. Kitchens and living rooms, which require natural light throughout the day, were placed in the southeast of communities, while bedrooms and dining areas, which are rarely used during the day, were placed in the west. towards order to offer enough sunshine for city dwellers, large buildings towards the northeast were avoided in the architecture of cities [88].

The Angkor Wat complex in Cambodia, which was formerly a Hindu temple, is one example of an ancient structure that incorporates these principles (Figure 13) [89]. Also, feng shui is a design philosophy that has its roots in ancient China and is centered on the idea of qi, or life force. According to feng shui, building and home qi cultivation is beneficial to health. In order to regulate the flow of qi, feng shui frequently offers "cures" such the purposeful and precise positioning of mirrors, plants, or sculptures. The human centric design ideas given throughout this design process can actually be

seen as the beginning of the use of neuro-science in architecture. And that is why they are seen as exemplary projects and plan organizations by modern architects.



Figure 13: The Angkor Wat Complex in Cambodia [89]

Their therapeutic landscapes were thoughtfully planned, taking into account architectural elements including the surrounding environment, built environment, feeling of place, and symbolic landscape, to aid in healing and well-being.

The end result is environments that not only respond to how our minds perceive their surroundings but also improve our well-being. Some design studies implemented by civilizations in ancient times are very similar to today's architectural approaches. Even though their names and definitions are different, these human-centric design processes continue for centuries [90].

#### **4.2.2 The Salk Institute for Biological Studies**

Traditionally, architecture has depended more on observation and intuition than on the experimental approach and evidence that make up the neurological study. However,

developments in neuroscience can now be used to explain how we perceive our environment, navigate through space, and how our physical environment might impact our cognition, problem-solving skills, and mood.

Jonas Salk was persuaded of the value of this interdisciplinary comprehension. As part of his legacy, Salk asked neuroscientists to work with architects to produce a project that would provide a creative physical work environment. Louis Kahn, one of the leading architects, was the architect of this project. This project which received the American Institute of Architect's award, has become one of the masterpieces and even pioneering structures in the field of neuro-architecture [91].



Figure 14: The Salk Institute for Biological Studies [91]

So as mentioned, Jonas Salk and Louis Kahn worked together to build an environmental design that would create workspaces that would foster creativity because they believed that the human mind always responds to architectural surroundings and from his personal experience at the Abbey. The Salk Institute accomplishes this by offering roomy, unrestricted laboratory areas that may be

modified to meet the rapidly evolving needs of science. According to Salk's request, Kahn filled the laboratories with light to provide a warm and stimulating setting for scientific investigation. Concrete, teak, lead, glass, and special steel were the building elements selected to help Salk achieve his vision for an awe-inspiring environment [92].

A wonderful study environment in a stunning setting is made possible by generous proportions, open structural spans that allow open labs and significant interior flexibility, modular lab components, and enough room for lab services. A full "interstitial" level with the ducts and pipes for the lab spaces is inserted between the floors housing laboratories and is a crucial component of the Salk building's airy design. By separating lab service distribution from the lab area inhabited by researchers, this architectural technique, which has been imitated in other newly constructed research institutes, makes maintenance and restoration easier. With glass walls encircling the open labs in the middle, Salk's floor layout incorporates outside pathways along the periphery (ideal for the temperate environment) [93].

The potential of all these environmental factors have ability to activate brain regions that regulate heart rate, focused attention, and alertness is known to improve problem-solving abilities and decrease error rates in decision-making at the cognitive level, according to some sources.

#### **4.2.3 Alzheimer's Respite Centre in Dublin**

According to Frederick Marks, a founding board member of the Academy of Neuroscience for Architecture and a specialist in building research and healthcare facilities, "The healthcare sector is predicated on evidence-based outcomes. The architectural sector is attempting to do the same thing with

neuroarchitecture. According to Marks, this activity data could be gathered in a structure like a hospital that was built with equipment expressly to monitor the heart rates or sleep patterns of its patients. “There’s an interaction between people and the building,” he adds.

Niall McLaughlin, a London-based architect and the founder of Niall McLaughlin Architects, is particularly interested in this issue as a result of his work on designing spaces for people with Alzheimer’s disease. According to McLaughlin;

“I wanted to know what was causing their loss of ability to navigate. It occurred to me that we would be much more mindful of the wonderful faculties we already possess if we understood what they were losing. We have a background from which to construct versions of the world when we comprehend the cognitive mechanisms that enable us to locate ourselves in time and space. The architecture of the resulting structure produces, calm, coherent spaces that aid orientation and encourage mobility”

Alzheimer's disease is recognized to have an impact on memory, reasoning, and language. Disorientation results from the gradual destruction of synaptic connections in the brain. It may have a significant impact on how people see themselves in the world. The difficulty in creating a care environment for people with Alzheimer's disease is reducing enervating distraction, assisting with orientation, and promoting mobility. Many persons with the condition can have their confusion, agitation, and disorientation reduced through design. By carefully evaluating the environment, architects want to encourage social contact and generate a greater sense of security.

The facility is located inside a former walled garden. Within this protected area, a network of connected pavilions with communal areas, tranquil gardens, and courtyards are set up for visitors to explore. A variety of naturally occurring pathways loop back on themselves, constantly bringing one back home. Through the use of meticulous,

custom-made wood details, a relaxing flow of the interior and exterior areas, and spacious, naturally lit rooms, the intention is to erase any institutional or medical character [94].



Figure 15: Facade of Alzheimer's Respite Centre [94]

According to the examinations and evaluations made in a study, some criterias were created to ensure that elderly people with Alzheimer's disease feel safe and healthy in the spaces. First of all a space should provide a comfortable and therapeutically environment to give friendly and domestic environment. To be able to do that, place should include matte finishes with bright colored textures, generous optimum lighting and a reduced number of anchor points. Space also should have sanitation, with contrasting colors in yellow-red spectrum, uniformed artificial lights, domestic exterior expressions. In order to avoid confusions simple designs should be applied to create a secure and safe atmosphere. And most importantly, space should use

optimum level of all wheelchair ramps, elevators, non-slip materials to provide flexibility and accessibility (Figure 16).



Figure 16: Public Spaces of Alzheimer's Respite Centre [94]

If the Alzheimer's Respite Center in Dublin case study is evaluated within the scope of these criterias, it is a project that will be considered very successful. By letting a lot of daylight in this project, the architect not only ensured a full and clear spatial perception, but also allowed the patients to receive vitamin D, which will contribute to the endorphin and serotonin hormone secreted in their bodies. At the same time, natural light and ventilation methods will regulate imbalances in the circadian rhythm. Likewise, patient-compatible materials used in the space will ensure that users are very comfortable and live safely.

#### 4.2.4 Groot Klimmendaal Children's Rehabilitation

Koen van Velsen's Rehabilitation Centre Groot Klimmendaal progressively widens out toward the summit and cantilevers out over the landscape. Despite its size, the roughly 14,000 sqm building blends in with its surroundings because to its brown-gold anodized aluminum façade [95].



Figure 17: Facade of Groot Klimmendaal Children's Rehabilitation [95]

According to the therapists, the building gives off the appearance of a spa rather than a rehabilitation facility because it is tucked between the trees and blends into the natural pattern of the woods. While some doctors disagree with evidence-based design, they do not discount the benefits of maintaining an open mind toward nature. A nearly seamless transition between the interior and outdoor is made possible by the full height windows running along the core area connecting the various internal building components. The restaurant's meandering facade creates a building in between trees and invites the forest within. Everywhere in the structure, there is a clear

visible and tactile presence of the surrounding nature, which enables users to revalidate their thoughts as they travel.

The structure and planning is clear. Offices are located below, clinical areas are located above, and a Ronald McDonald House with its own identity is located on the roof. The specific program components, including a sports facility, fitness center, swimming pool, restaurant, and theater, are made possible by the double-height ground floor at entrance level. These facilities are frequently used by patients, their families, as well as locals (schools, theater companies, etc.). As a result, the patient and the building are given a central position in the neighborhood.

The care model is predicated on the notion that a supportive and stimulating atmosphere improves patients' wellbeing and aids in their revalidation process. The goal of the design was to construct a structure that was integrated into its surroundings and the community rather than one that had the look of a health center.

'Groot Klimmendaal', a revalidation center, exudes self-assurance and restraint. The warm and open setting provides a natural home for care while also providing lots of opportunities for other pursuits. Koen van Velsen, the architect, worked closely with the building's users to create the structure. For instance, the new integral style of working is typified by a modest timber staircase that spans the entire interior height of the structure. It makes it easier to travel directly between floors while also making it possible to take a number of detours around the building, which serves as an invitation to engage in physical activity. The 30 meters wide building's 30 separate floors are spatially connected by a mix of large and small gaps and light wells, which also allow

for natural illumination deep inside the structure. The room is made more vibrant by the interaction of vivid but subtle colors and direct and indirect (artificial) lighting. Families will benefit from the building's abundant natural light and scenery by feeling less stressed. When seen from the perspective of the medical staff, the transparency between the spaces allows for simple supervision (Figure 18).

However, some post-occupancy issues, including upkeep expenditures, expose the building's negative aspects. Large glass facades for Holland's climate increase heating costs. Another issue with hygiene is that it's difficult to keep the corners and edges clean, which can be problematic for open wounds. Other issues with the transfers inside the facility were also raised.

From a neuro-architectural perspective, the structure places a heavy emphasis on staff and patient relaxation. Relaxation and reduced tension will improve the effectiveness of therapies, which will ultimately shorten the time needed for recovery [96].



Figure 18: Interior of Groot Klimmendaal Children's Rehabilitation [95]

### 4.3 Chapter Summary

The colors, materials, natural and artificial light sources, harmony of the space with nature, ventilation and smell used in space design have a great impact on user. In line

with the results obtained from all these case studies, it was discussed how useful it could be to create user-oriented designs.

Especially healthcares, workplaces and educational spaces are of great importance as they host different numbers of people from different age groups. For this reason, as examined in case studies, harmony with nature in such spaces, the importance of natural or artificial light sources, the harmony of the materials used and the colors used in the space were examined. As mentioned, this subject has become a project whose implementations has increased with the developing technology today and the importance of user oriented design of spaces now gaining more value.

## Chapter 5

### CONCLUSION

Although there is no pre-made blueprint for applying neuroarchitecture, there are several specifics that can be seen in the way places are built. For instance, depending on the type of project, it is vital to pay attention to the sounds of the environment in acoustics. Do noises from the streets interfere with your ability to focus or sleep? Would the usage of acoustic materials be required? How much does an extremely open coworking office hinder productivity if it's a work environment? When it comes to lighting, architects also need to pay attention to how light enters the room. Natural light is more comfortable for the human body, but what hues and levels of brightness won't produce glare if a lot of artificial light is required? The usage of yellow lights, which are cozier, may be more practical in a relaxing environment like a restaurant or even a home. Perhaps other hues, such as blue and orange, which are known to be refreshing, might be more engaging if it were a hospital, a healing and treatment setting. Curves would be more intriguing when it comes to furniture in a kindergarten, for instance, than corners, which imply danger and terror and can cause certain youngsters to become fearful and reactive. Additionally, it is well recognized that plants fosters a sense of connection to nature, which not only improves the indoor air quality but also calms visitors [97].

Over the past 50 years, a large number of scientists, architects, and experts from various industries have ardently promoted and championed the ideas of

neuroarchitecture, advancing the topic to where it is at this point. The fields of architecture and interior design can innovate for new learning in neuroarchitecture as neuroscience develops. "As neuroscience develops, so does our comprehension of the role that space might play in mediating neurophysiology. examining things like our heart rates or the regions of our brains that light up when we see anything lovely or cozy about workplace decor. According to Schuller, neurology is not deterministic, just like architecture is not. It goes without saying that the mind and body are composed of very complicated systems and processes. A holistic approach that considers the complete space, as well as its environmental quality, may be more effective than attempting to elicit a psychological or psychological response with a single design feature.

In the end, neuroarchitecture is another tool that can be used to create future cities that will enhance the inhabitants' social interactions and physical health. In light of the UN's prediction that by 2050, two-thirds of the world's population will reside in urban areas, applying neuroarchitecture to urban planning may lead to the creation of cities that are specifically tailored for the needs of their inhabitants.

According to some academics, this field has a promising future and that neuroscientists and psychologists may help architects, designers, and city planners better realize their dreams by fostering an awareness of their demands.

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