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Impact of Architectural Forms on Human Perception- A Neurocognitive Experimentation

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Abstract
The form or shape of the built environment is fundamental to architectural design, but not many studies have shown the impact of different forms on the inhabitants' consciousness. This study will investigate the neurological correlates of different interior forms on the perceivers' affective state and the accompanying brain activity. There exists a measurable and predictable relationship between the effect of the architectural form of buildings on their users' brain wave frequencies, and then their consciousness status. Leveraging Electroencephalography (EEG), we quantitatively capture brainwave patterns as participants navigate diverse architecturally designed spaces virtually. Key objective is the development of a scientific measuring tool, aiding architects and designers in creating spaces tailored to desired consciousness states for optimal user experience and well-being.
Keywords: Architectural Design; Form and Shape; Neurophysiological Correlates; Brain Activity; Neurocognitive Experimentation; Electroencephalography; BioGeometry; Neuroarchitecture.

1. Introduction

The search for the right way to design architectural spaces is one of the most enduring and fundamental questions in the field of architecture. Aspiring to improve the built environment, architects are continually trying to create spaces that positively affect users. Recent technological advances in architectural design and simulation methods allow architects to empirically examine and optimise numerous criteria that affect users (Grobman 2011). These criteria are primarily related to environmental aspects such as stability, light, temperature and acoustics (Hensen and Lamberts 2011). However, perceptual and cognitive criteria, which are crucial to understanding the influence of architectural space on people, are still evaluated by relying on the designer's experience or on rules-of-thumb.

The aim of the presented research is to investigate whether emotional and cognitive reactions that are generated by various types of architectural spaces can be empirically measured and quantified. The argument is that current technological advances in virtual reality (VR) tools and techniques, electroencephalogram (EEG), data analysis methods and neuroscience research may point at new ways to recognize, quantify and measure human affective response in relation to architectural space.

The argument in this paper is developed as follows: first, we critically review the current stage of knowledge in the field, define the gaps in measuring human affective response to architectural space and discuss the potential of recent technological advances to recognize different experiences in architectural space; second, we examine human affective response to different architectural space geometries in a VR environment. Third, we develop and test a framework for a research methodology and experiment setup that will enable empirical examination of human responses to architectural space geometry, based on a combination of VR and EEG data.

We begin with a literature review, which explores current knowledge on shape perception and spatial perception. Specifically, we discuss the relationship among space perception, cognition and emotions. The second part presents an experiment that examines the connection between space geometry and participants' affective response using questionnaires and a VR based setup. Finally, we will present findings from a preliminary empirical experiment based on the combined use of a wireless EEG and a manifold learning data analysis method that shows that different types of architectural space geometry generate different brain reactions. The paper ends with a discussion of directions that are worth pursuing in the future stages of the research.

2. Literature Review

2.1. Neuroarchitecture

Neuroarchitecture is an interdisciplinary field that explores the intricate relationship between the design of our built environment and the functioning of the human brain. At its core, neuroarchitecture seeks to understand how architectural elements and spatial configurations impact our cognitive processes, emotions, behaviours, and overall well-being. By integrating insights from neuroscience, architecture, psychology, and physiology, neuroarchitecture aims to inform the design of environments that are not only aesthetically pleasing and functional but also conducive to human health, productivity, and happiness.

Here's a deeper dive into what neuroarchitecture entails:

1. Neuroscience: Neuroscience forms the foundation of neuroarchitecture. It involves the study of the brain and nervous system, including how neurons communicate, how sensory information is processed, and how different brain regions function. In neuroarchitecture, neuroscientific research helps uncover how architectural stimuli

affect neural activity and cognitive processes. For example, studies using brain imaging techniques like fMRI or EEG can reveal how specific architectural features, such as natural light or open spaces, influence brain function and emotional responses.

2. Architecture: Architecture encompasses the design and construction of buildings, landscapes, and urban spaces. In neuroarchitecture, architects apply principles derived from neuroscience to create environments that optimise human experiences. This involves considering factors such as spatial layout, lighting, colour, materials, acoustics, and ventilation. For instance, architects might design spaces with ample natural light and views of nature to promote mental well-being and reduce stress. They may also incorporate elements of biophilic design, which seeks to reconnect occupants with nature, to enhance cognitive performance and creativity.
3. Psychology: Psychology contributes to neuroarchitecture by examining how architectural design influences human behaviour, emotions, and social interactions. Psychologists study topics such as environmental psychology, which explores the relationship between people and their surroundings, as well as cognitive psychology, which investigates how mental processes like perception and attention are influenced by environmental stimuli. In neuroarchitecture, psychologists help identify design strategies that foster positive emotions, enhance wayfinding, promote social interaction, and support user well-being.
4. Physiology: Human physiology plays a crucial role in shaping our physiological responses to the built environment. Factors such as temperature, humidity, air quality, and ergonomic design can impact our comfort, health, and productivity. In neuroarchitecture, designers consider physiological needs and preferences to create environments that support physical well-being. For example, they may implement strategies for thermal comfort, optimise indoor air quality, or design ergonomic furniture to reduce physical strain and fatigue.

Neuroarchitecture emphasises an integrative approach that considers the complex interactions between the brain, body, and environment. By understanding how architectural design influences our neural and physiological processes, designers can create environments that promote holistic well-being and enhance the quality of life for occupants. Whether it's designing healthcare facilities that support healing and recovery, educational environments that facilitate learning and creativity, or urban spaces that foster social connection and community engagement (Amen & Kuzovic, 2018; Amen & Nia, 2021; Abdulla & Abdelmonem, 2023; Afolabi & Adedire, 2023), neuroarchitecture offers a transformative perspective on the power of design to positively impact human health and happiness.

2.2.Biogeometry

BioGeometry is a design language developed by Dr. Ibrahim Karim, which integrates geometric shapes and principles to harmonise biological energy fields in the environment. It aims to balance and enhance the energy quality of spaces, influencing the physical, emotional, and mental states of the inhabitants.

Principles of BioGeometry-

- Energy Fields and Resonance: BioGeometry is based on the concept that every shape and form has its own energy signature. These energy fields interact with the energy systems of living organisms.
- BioGeometry Signatures: Specific geometric shapes, known as BioGeometry Signatures, are central to this practice. These shapes are carefully designed to harmonise and balance energy fields.
- Shape, Angles, and Proportions: By employing specific geometric configurations, BioGeometry practitioners aim to align and optimise energy flow within a space.
- Harmonisation and Balancing: One of the primary goals of BioGeometry is to create harmony and balance in an environment. This is achieved by adjusting the shapes and spatial arrangements to align with natural energy flows.

Application in Architecture-

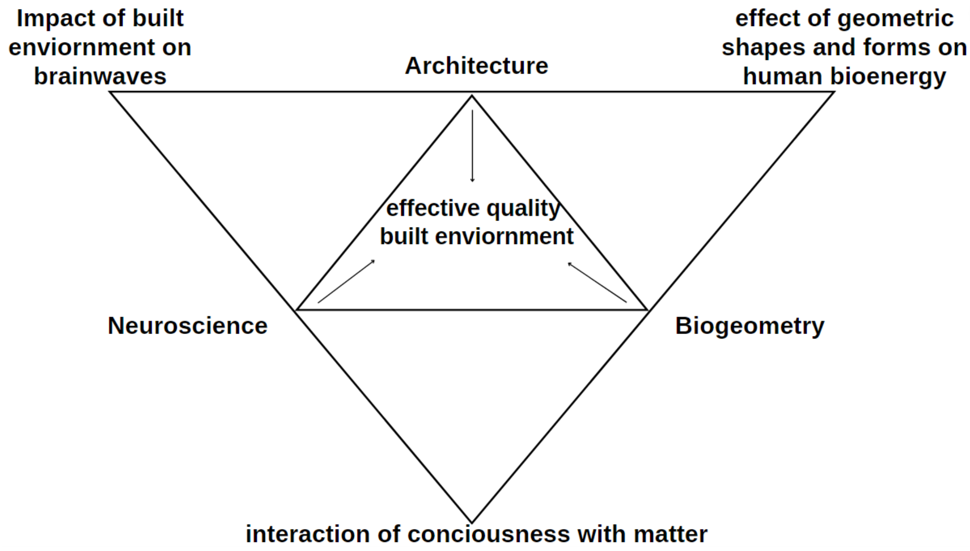
BioGeometry has been applied in various architectural projects to create spaces that promote health and well-being. By integrating specific geometric forms and proportions, architects can design environments that resonate positively with the inhabitants' energy fields. This approach is particularly relevant in healthcare and residential design, where the well-being of occupants is paramount.

Human BioEnergy and Human consciousness

The research by Elbaiuomy et al. (2019) investigates the hypothesis that the geometric forms of architectural spaces can influence users' consciousness states through resonating frequencies. Using CST Microwave Studio for simulation, they explored how different shapes and materials resonate at specific frequencies, impacting the user's bioenergy. The findings demonstrate a significant relationship between the form of a building and the consciousness state of its occupants, suggesting that architectural designs can evoke particular mental statuses. This supports the idea that spaces act like antennas, resonating at particular frequencies that affect human consciousness.

Link between BioGeometry and Neuroarchitecture-

Neuroarchitecture explores the relationship between architectural design and brain function, focusing on how built environments influence neural activity and mental states. BioGeometry provides a complementary approach by emphasising the energetic quality of spaces, which can also impact neurophysiological responses.



2.3. The effect of brain frequencies on statuses of consciousness-

The human brain constructs our experience of the world through a constant interplay of sensory inputs. Vision plays a particularly crucial role in architectural perception. As Rudolph Arnheim aptly stated in his seminal work, "Art and Visual Perception," we perceive objects and spaces not as isolated entities, but rather as a complex interplay between their physical characteristics and our own visual system.

Shape, scale, light, and colour all contribute to the overall "sensory language" of an architectural environment. A soaring cathedral with its pointed arches and high ceilings evokes feelings of awe and reverence, while a cosy cafe with its rounded furniture and warm lighting might induce feelings of relaxation and comfort. These emotional responses are not merely subjective musings – they are rooted in the very way our brains process and interpret the world around us. Understanding the brain's response to architectural forms involves studying brainwaves, which reflect the electrical activity of brain cells.

Brain waves-Brain Waves are very accurate electrical signals reflecting the changes which occur in the frequency of brainwaves during different mental statuses. Studying brain waves has a key role in understanding how the human brain and mind work and the relationship between the neurological functions and the main brain parts. The electrical activity of the brain is actually defined as the collection of all activities of brain cells.

Brainwaves are classified into five major types: Delta, Theta, Alpha, Beta, and Gamma waves, each associated with different states of consciousness such as alertness, relaxation, and sleep. Delta waves (0-4 Hz) are linked to deep sleep, Theta waves (4-8 Hz) to light sleep and relaxation, Alpha waves (8-12 Hz) to relaxation and calmness, Beta waves (12-40 Hz) to active thinking and concentration, and Gamma waves (40-100 Hz) to high-level cognitive functioning.

Brainwave frequencies can be influenced by external stimuli, including architectural forms. For instance, certain shapes and spatial configurations might induce relaxation by promoting alpha waves, while others might enhance concentration by stimulating beta waves.

Frequency	Unit	Consciousness status
Delta brainwaves (0.5–4 Hz)		
0.5	Hz	Relax—help to soothe headaches
0.5–1.5	Hz	Relieve pain
0.9	Hz	A sense of joy
1.0	Hz	The feeling of well-being—the harmony and balance
2.5	Hz	Relieve pain and reduce anxiety
2.5	Hz	Relieve migraine pain
3.4	Hz	Help achieve restful sleep
3.5	Hz	Autism with the outer perimeter
3.9	Hz	Promote internal awareness
4.0	Hz	Reduce stress
4.0	Hz	Enhance the memory capacity—enhance learning ability
Theta brainwaves (4–8 Hz)		
4.9	Hz	Induces relaxation, meditation and deep sleep
5.35	Hz	Relax and breathe freely and efficiently
5.5	Hz	Internal guidance and intuition
6.5	Hz	Activate creativity
7.5	Hz	Technical and creative thought
7.5	Hz	Ease of overcoming the nagging issues
7.8	Hz	Schumann frequency waves—activity and balance
Alpha brainwaves (8–12 Hz)		
8.0–10.0	Hz	Learning new things depending on the memory
10.0	Hz	Improve the status of general mood
11.0	Hz	Relax status after waking up
12.0	Hz	Moderation and mental stability
Beta brainwaves (12–40 Hz)		
14.0	Hz	Attention—focus on tasks and vitality
12.0–15.0	Hz	Concentration and relaxation
13.0–27.0	Hz	The attention to external stimuli focus
13.0–30.0	Hz	Problem solving and conscious thinking
18.0–27.0	Hz	A sense of euphoria (euphoria)

2.4. Form defining space

Form is an inclusive term with several meanings. It may refer to an external appearance that can be recognized, such as a chair or the human body sitting in it. It can also denote a particular condition in which something acts or manifests, like water in the form of ice or steam. In art and design, form often refers to the formal structure of a work—the arrangement and coordination of elements and parts to create a coherent image.

Space constantly encompasses our being. Through the volume of space, we move, see forms, hear sounds, feel breezes, and smell the fragrances of a blooming flower garden. Although space is a material substance like wood or stone, it is an inherently formless vapour. Its visual form, dimensions, scale, and quality of light all depend on our perception of the spatial boundaries defined by elements of form. When space begins to be captured, enclosed, moulded, and organised by elements of mass, architecture comes into being. The interplay between form and space is fundamental to architectural design, shaping how we experience and interact with our environment. By understanding and manipulating these elements, architects create spaces that are both functional and aesthetically pleasing.

The relationship between form and space is dynamic and reciprocal. Forms define and shape space, while space, in turn, influences the perception and experience of forms. Architectural forms create spatial boundaries, dividing space into functional areas and guiding circulation patterns. The size, scale, and arrangement of forms within space determine spatial qualities such as proportion, rhythm, and hierarchy. At the same time, the spatial context influences the appearance and expression of forms, framing views, and shaping light and shadow patterns.

Form defining space is a fundamental concept in architecture, describing how physical elements shape and give structure to the otherwise formless expanse of space. In this process, architectural forms such as walls, floors, ceilings, and structural features delineate spatial boundaries, establishing the dimensions, scale, and character of the space. These forms not only partition space but also imbue it with functionality, perceptibility, and suitability for human interaction.

At its core, form defining space is about transforming abstract space into a structured environment that influences human experience. Without these defining elements, space remains amorphous and undefined, lacking the organisation necessary for human inhabitation. Walls create enclosure, delineating rooms and defining boundaries between interior and exterior spaces. Floors establish levels and surfaces for movement, while ceilings provide overhead enclosure and define spatial volume.

The interaction between architectural forms and space is dynamic and reciprocal. As physical forms shape space, space, in turn, influences the perception and experience of these forms. The spatial boundaries created by architectural elements guide our movement, directing us through sequences of spaces and shaping our spatial awareness. Additionally, the scale and proportion of architectural forms relative to human scale play a crucial role in how we perceive and navigate space. A large, open room may evoke a sense of expansiveness and freedom, while a narrow corridor might feel constricting and enclosed.

2.4.1 Perception of Architectural Forms

Vision plays a crucial role in identifying potential resources or dangers, essential for survival (Rosenzweig, Leiman, & Breedlove, 1999; Bar, 2004). Perception involves the interplay between the physical characteristics of an object and the viewer's nervous system. In the context of architecture, perception is influenced by factors such as form, colour, texture, and lighting. Perception of architectural forms is a multifaceted process that involves the intricate interplay between sensory stimuli, cognitive processing, and emotional responses. Here's a detailed exploration of how individuals perceive architectural forms:

1. Spatial Perception: Spatial perception refers to the ability to perceive and navigate through three-dimensional space. Architectural forms influence spatial perception by shaping the way individuals move, orient themselves, and interact with their environment. Spatial cues such as depth, perspective, and spatial relationships between objects guide people's understanding of spatial layout and organisation. For instance, the arrangement of rooms within a building, the configuration of pathways in a public square, or the layout of streets in a cityscape all impact how individuals perceive and navigate through space.
2. Temporal Perception: Temporal perception involves the perception of time and the sequencing of events within architectural environments. Buildings and spaces can evoke a sense of temporal continuity or change through architectural elements such as rhythm, pacing, and movement. For example, the design of a museum may guide visitors through a carefully choreographed sequence of spaces, creating a narrative experience that unfolds over time. Similarly, dynamic architectural features such as moving facades, kinetic sculptures, or interactive installations engage people's temporal perception, inviting them to participate in the unfolding of architectural experiences.
3. Emotional Perception: Architectural forms can elicit a wide range of emotional responses, from awe and inspiration to tranquillity and comfort. Emotional perception is influenced by factors such as aesthetics, cultural meaning, personal associations, and environmental context. For instance, the design of a religious monument may evoke feelings of reverence and spirituality, while a cosy café with warm lighting and soft furnishings may evoke feelings of intimacy and relaxation. Architects carefully consider the emotional impact of architectural forms, using elements such as scale, materiality, colour, and light to create atmospheres that resonate with occupants' emotions and aspirations.
4. Cognitive Perception: Cognitive processes such as attention, memory, and interpretation also shape how individuals perceive architectural forms. Architectural designs may incorporate cognitive cues such as focal points, landmarks, and wayfinding signage to guide people's attention and facilitate navigation. Moreover, architectural forms can convey symbolic meanings, cultural references, and narrative interpretations that engage people's cognitive faculties and stimulate intellectual curiosity. For example, the design of a library may incorporate elements that evoke the pursuit of knowledge and the discovery of new ideas, fostering a sense of intellectual engagement and exploration among visitors.

Overall, the perception of architectural forms is a rich and dynamic phenomenon that engages multiple sensory modalities, cognitive processes, and emotional experiences. By understanding how individuals perceive and interpret architectural environments, designers can create spaces that not only fulfil functional requirements but also resonate with people's sensory, emotional, and cognitive needs, enhancing the quality of human experience in the built environment.

5. Visual Perception in Architecture

Vision is one of the primary senses through which individuals perceive architectural forms. When encountering a building or space, people quickly process visual information such as shape, scale, proportion, symmetry, and texture. For example, the façade of a building may feature geometric patterns, intricate details, or contrasting materials that capture attention and evoke visual interest. Architectural elements like columns, arches, and windows not only serve functional purposes but also contribute to the overall visual composition, creating a sense of harmony, balance, and rhythm.

Architectural design often relies on visual perception to create spaces that are aesthetically pleasing and functionally effective. According to Rosenzweig, Leiman, and Breedlove (1999), visual perception involves complex cognitive processes that interpret sensory input from the environment. Bar (2004) adds that the brain uses contextual information to recognize and understand objects, which is crucial in a designed environment.

In architectural spaces, visual perception is not only about recognizing forms but also about experiencing the environment in a way that elicits certain emotions and cognitive responses. This makes the study of visual perception fundamental to understanding how architectural forms impact human experience.

3. Methodology and Experiment

3.1.Understanding cognitive aspects of Human brain and consciousness

Understanding the dynamics and computation of a single neuron and its role in a large neural network is crucial in the study of neuroscience because brain function relies on the interplay of millions of these neurons. Many aspects of brain functions and behaviour of the human body can only be discussed based on how information is transmitted from neuron to neuron. All cognitive processes inside a brain are carried out with neuronal activity consisting of synapsing and spike generation in a network of neurons. Electroencephalography is the recording of the electrical activity of the brain due to the firing of neurons inside a brain by placing multiple electrodes on the scalp. Apart from EEG, some other non-invasive technologies like MEG (Magnetoencephalogram) and fMRI (functional Magnetic Resonance Imaging) are also available to track different aspects of mental processes. EEG, being simple, portable and economical, stands out of being a promising tool capable of measuring neuronal function in different operational environments.

Aspects of Cognition and consciousness :

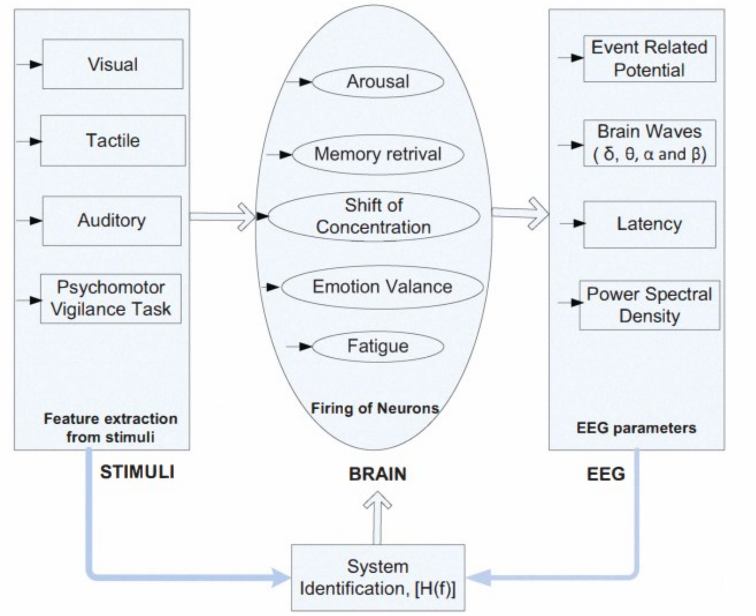
Memory: Memory is attributed to encoding, storage and retrieval of information from the brain. Parts of the brain like the amygdala, hippocampus and striatum are involved in the specific types of memory.

Emotion Valance: Frontal EEG asymmetry has been the issue of discussion in transforming EEG to metrics that can provide inferences about the emotional state of a person. A greater left frontal brain activity to be associated with the positive valence of mind while the greater right frontal brain activity to be related to negative valence.

Fatigue: Fatigue is a state of decrease of performance which may be due to various reasons like deprivation of sleep or from continuous physical or mental workload.

Distraction: Distraction is a mental process that causes shift of attention.

Arousal: Arousal is a state of mind of being awake and highly alert to respond to stimuli.



3.2.Electroencephalography(EEG)

Electroencephalography (EEG) is a non-invasive neuroimaging technique used to measure and record electrical activity in the brain. EEG equipment consists of several components designed to capture and analyse the electrical signals generated by neurons in the brain.

Electroencephalography is the recording of the electrical activity of the brain due to the firing of neurons inside a brain by placing multiple electrodes on the scalp. Apart from EEG, some other non-invasive technologies like MEG (Magnetoencephalogram) and fMRI (functional Magnetic Resonance Imaging) are also available to track different aspects of mental processes. EEG, being simple, portable and economical, stands out of being a promising tool capable of measuring neuronal function in different operational environments. The feasibility of using the psychophysiological metrics obtained from EEG to determine fatigue, workload and performance in military and industries has been discussed in. With the advent of digital wireless EEG and the integration of robust software, real time analysis is now possible to monitor the alertness and cognitive workload in an operational environment.

3.3 Virtual environment

Virtual environment refers to a computer-generated simulation of architectural spaces and environments that allows designers, clients, and stakeholders to explore, interact with, and experience architectural designs in a digital format.

Presence and immersion are key concepts in the realm of virtual environments, describing the extent to which users feel as if they are truly "present" within a digital space and are engaged in a compelling and realistic experience. Here's a brief overview:

1. Presence: Presence refers to the subjective sensation of being physically present within a virtual environment, despite knowing on a rational level that one is actually in a different physical location. It encompasses the feeling of "being there" and experiencing a sense of spatial presence, where users feel as if they are occupying and interacting with the virtual space as if it were real. Presence is influenced by factors such as sensory fidelity (how accurately the virtual environment replicates real-world sensory experiences), interactivity (the degree to which users can interact with objects and entities within the virtual environment), and immersion (the degree of engagement and absorption in the virtual experience).

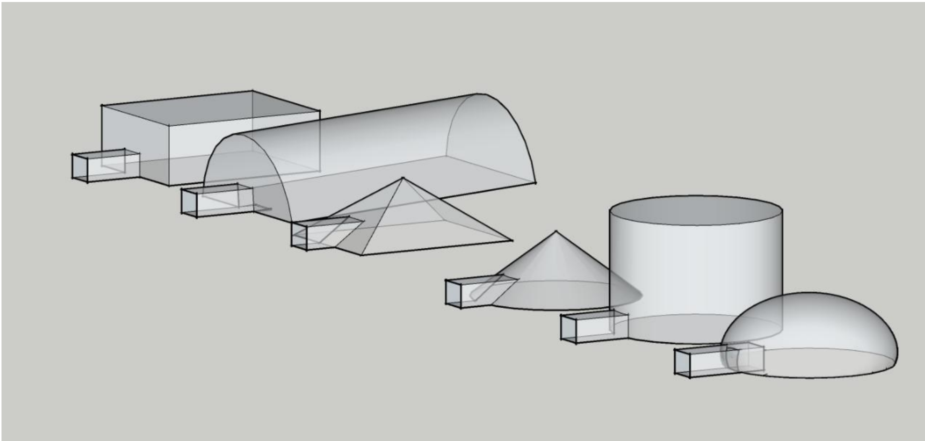
2. Immersion: Immersion refers to the degree of engagement and involvement that users experience when interacting with a virtual environment. It goes beyond mere visual and auditory fidelity to encompass psychological and emotional factors that contribute to a feeling of "being lost" or "transported" within the virtual world. Immersive experiences are characterised by a high level of user agency, where users feel empowered to explore, interact, and influence the virtual environment in meaningful ways. Immersion can be enhanced through techniques such as narrative storytelling, realistic graphics and sound design, responsive feedback systems, and social interaction with other users.
Presence and immersion are closely related concepts that describe the sense of "being there" and the degree of engagement and absorption in a virtual environment. Achieving a high level of presence and immersion is a key goal in the design and development of virtual reality applications, as it enhances the sense of realism, agency, and emotional impact of the virtual experience, ultimately creating more compelling and impactful user experiences.

3.4. Experiment

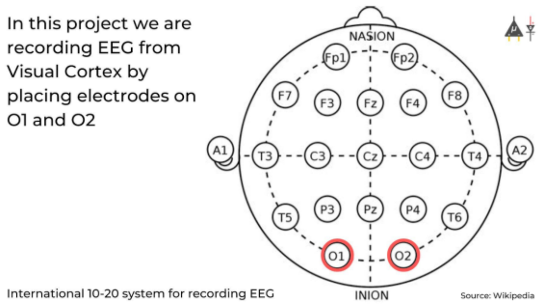
3.4.1. Experiment Aim

The aim of this study is to investigate how different fundamental architectural forms influence brainwave patterns, using virtual reality (VR) environments and EEG data analysis.

3.4.2. Experiment Setup



1.Visual Environment setup- The setup consisted of six types of VEs: Cuboid, Vault, Square pyramid, Cone, Cylinder, Sphere. In order to perform an optimal comparison of impact of architectural form over the user, all designs had to maintain comfortable proportions and a sense of human scale. A space too small might create an instantaneous feeling of suffocation, while a space too large might create discomfort or disorientation. As such, all spaces were designed to be approximately the same size. Volumes were designed to be colourless (monochromatic), soundless, with no objects. The lighting was non-directional and created equal illumination in all parts of the space.



2.EEG data collection- EEG data is collected using a high-resolution, 2-channel headset, capable of capturing detailed brainwave patterns. The data is analysed to identify the predominant brainwave frequencies in response to each architectural form, providing insights into the neurophysiological impact of different designs.

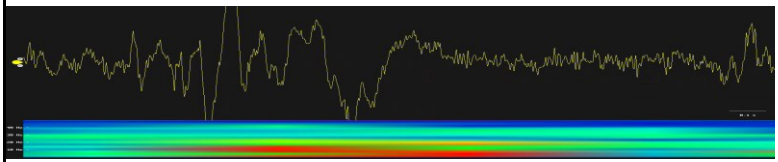
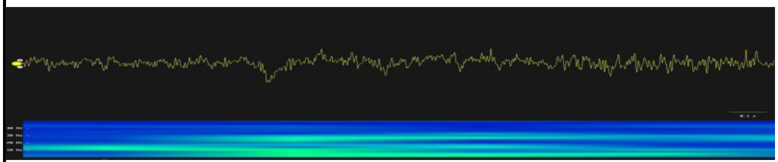
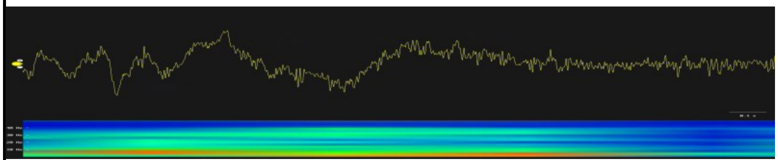
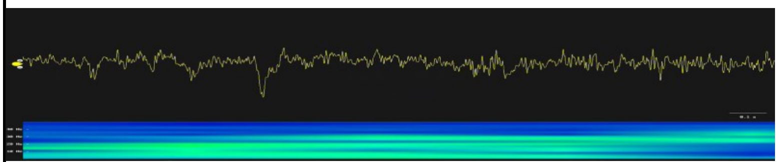
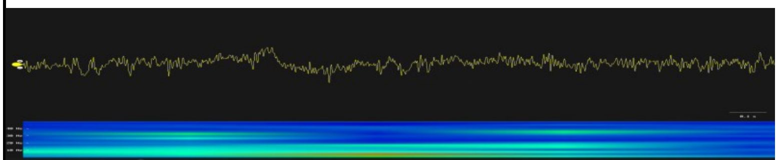
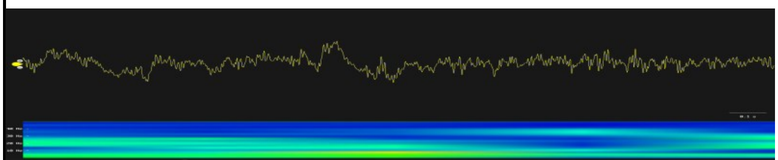
3.4.2. Experiment procedure

1.The experiment began with the participant entering the space by 'walking' through a standard corridor followed by a door. This stage is important, as researchers found that entering a room or walking through doorways can facilitate forgetting or evoke one's memory (Ballard et al. 1997; Radvansky and Copeland 2006). Wang and Spelke (2000) found that human navigation through a layout in an unfamiliar environment depends on an updating representation process of target's positioning relative to the self, which occurs during movement. Therefore, participants were asked to 'walk' towards the form, explore the space and leave (through the same door) as they finish.
2.Participants are introduced to the study and provided with instructions on navigating the VR environments. They wear EEG headsets and are guided through a series of 5 fundamental architectural forms for 5 minutes , in each environment.
EEG data is continuously recorded as participants navigate the VR environments.
3.The EEG signals from the participants are recorded while frames of different spaces (observed from the entrance) are presented to them on the virtual reality console. Then these EEG signals are analysed by the means of an FFT graph, and a conclusion for various architectural forms is drawn.

4. Results

4.1. EEG data analysis

The analysis reveals distinct brainwave patterns in response to different architectural forms. The results indicate that specific geometric features can influence mental states and emotional responses, providing empirical evidence to support the hypotheses.

FORMS	FREQUENCY(HZ)		CONSCIOUSNESS STATUS
CUBOID		9hz	Learn new things
VAULT		4-8hz	Stress reduction
SQUARE PYRAMID		4-8hz	Stress reduction
CONE		25hz	Attention, focus
CYLINDER		10hz	Learn new things, relaxed
SPHERE		8hz	Learn new things, Stress reduction

4.1.1 Alpha Waves

Alpha waves are predominant in spaces with simple, symmetrical forms, such as cuboids and cylinders. This suggests that these forms promote relaxation and calmness, aligning with the principles of BioGeometry, which emphasises harmonious and balanced shapes.

4.1.2 Beta Waves

Beta waves are more pronounced in spaces with complex, asymmetrical forms, such as pyramids and cones. This indicates heightened cognitive engagement and active thinking, supporting the idea that certain architectural forms can stimulate mental activity and concentration.

4.2. Subjective feedback

Participants' feedback corroborates the EEG data, with many reporting feelings of relaxation in symmetrical spaces and increased alertness in asymmetrical spaces. This subjective feedback provides additional validation for the findings, highlighting the impact of architectural forms on perception and consciousness.

4.2.1. Relaxation and Calmness

Participants consistently report feeling more relaxed and calm in spaces with simple, symmetrical forms. This aligns with the increased alpha wave activity observed in these environments, suggesting a strong correlation between form and emotional response.

4.2.2. Cognitive engagement

In contrast, participants report feeling more alert and mentally engaged in spaces with complex, asymmetrical forms. The increased beta wave activity in these environments supports this feedback, indicating that these forms stimulate cognitive processes.

5. Discussions

5.1. Interpretation of results

The results provide evidence that different architectural forms elicit distinct brainwave patterns, influencing mental states and emotional responses. This supports the hypothesis that architectural design can significantly impact human perception and consciousness.

The findings align with the principles of BioGeometry, which emphasise the use of harmonious shapes to promote well-being. The increased alpha wave activity in symmetrical spaces suggests that these forms create a balanced energy field, promoting relaxation and reducing stress.

The results also support the concepts of Neuroarchitecture, indicating that certain architectural forms can stimulate cognitive engagement. The increased beta wave activity in complex, asymmetrical spaces suggests that these forms enhance mental activity, potentially improving productivity and creativity.

5.2. Comparison with previous studies

The findings align with existing literature on shape perception and spatial perception, providing empirical evidence to support theoretical concepts. Previous studies have suggested that architectural form influences perception and behaviour, but this study provides concrete data on the neurophysiological correlates of these effects.

The study's results support theories that propose a link between spatial geometry and mental states. By providing empirical evidence of this relationship, the study contributes to a deeper understanding of how architectural design can impact human experience at a neurophysiological level.

Previous research has indicated that certain geometric shapes and configurations can influence brainwave patterns and mental states. This study provides additional empirical evidence, demonstrating that specific architectural forms can elicit distinct neurophysiological responses, supporting the integration of BioGeometry and Neuroarchitecture.

5.3. Implications

The study offers practical implications for architects and designers, suggesting that specific geometric forms can be used to induce desired psychological and physiological states in users. This has significant implications for various fields, including healthcare, education, and workplace design.

5.3.1. Healthcare design

Spaces in hospitals and clinics can be designed to promote relaxation and reduce stress, aiding in patient recovery and well-being. By incorporating symmetrical, harmonious shapes, healthcare environments can create a calming atmosphere that supports healing.

5.3.2. Educational environment

Classrooms and study areas can be designed to enhance concentration and cognitive engagement, improving learning outcomes. By incorporating complex, asymmetrical forms, educational spaces can stimulate mental activity and creativity.

5.3.3. Workplace design

Offices and workspaces can be designed to foster creativity and productivity, enhancing employee performance and satisfaction. By integrating diverse geometric forms, workplace environments can promote both relaxation and cognitive engagement, supporting a balanced work experience.

6. Conclusions

6.1. Summary of findings

The study identified a measurable relationship between architectural forms and neurophysiological responses. Different geometric forms were found to influence brainwave frequencies, guiding consciousness to specific states. The findings provide empirical evidence that architectural design can significantly impact human perception and consciousness.

6.1.1. Neurophysiological responses

The study demonstrated that specific architectural forms elicit distinct brainwave patterns, influencing mental states and emotional responses. This provides concrete data to support the hypothesis that architectural design can impact neurophysiological processes.

6.1.2. Practical applications

The findings offer practical insights for architects and designers, suggesting that specific geometric forms can be used to promote desired psychological and physiological states in various environments, including healthcare, education, and workplaces.

6.2. Recommendations

Broader Range of Forms: Future studies should include a wider variety of architectural forms and spatial configurations to explore their impact on brain activity and consciousness.
Real-World Settings: Conducting experiments in real-world architectural spaces can validate the findings and provide more comprehensive insights.
Longitudinal Studies: Long-term studies can investigate the sustained impact of architectural forms on mental states and well-being.
Developing scientific measuring tools that incorporate EEG and other biometric data can aid architects in designing spaces that promote desired psychological states, enhancing overall user experience and well-being.

6.3. Final thoughts

This research bridges neuroscience and architectural design, offering evidence-based insights into the impact of architectural forms on human perception and consciousness. By understanding the neurophysiological correlates of architectural forms, architects can design spaces that promote desired psychological states, enhancing overall user experience and well-being. The integration of BioGeometry and Neuroarchitecture offers a holistic approach to architectural design, providing a comprehensive understanding of how spaces impact human well-being at both a physical and energetic level.

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Conflict of Interests

The Author(s) declare(s) that there is no conflict of interest.

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