ISTANBUL TECHNICAL UNIVERSITY ★ GRADUATE SCHOOL

AN ARCHITECTURAL RESEARCH FRAMEWORK FOR THE NEUROSCIENCE OF HUMAN EXPERIENCE

Ph.D. THESIS

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Department of Architecture

Architectural Design Programme

OCTOBER 2023

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ISTANBUL TEKNİK ÜNİVERSİTESİ ★ LİSANSÜSTÜ EĞİTİM ENSTİTÜSÜ

İNSAN DENEYİMİNİN NÖROBİLİMİ İÇİN BİR MİMARİ ARAŞTIRMA ÇERÇEVESİ

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Date of Submission : 22 August 2023
Date of Defense : 24 October 2023

Dedicated to my preciouses; YİĞİT and İZGİ

FOREWORD

Completing this thesis would not have been possible without the valuable support of my mentors, colleagues, friends, and family. First and foremost, I would like to express my sincere gratitude to my advisor, Assoc. Prof. Dr. Dilek YILDIZ OZKAN for her open-hearted and open-minded attitude and tremendous support, and my co-advisor, Assoc. Prof. Dr. Gökhan INCE for enthusiastic encouragement, endless support and care, and rigorous approach throughout my doctoral studies. I'd also like to thank my thesis committee members, Prof. Dr. Yüksel DEMIR, Prof. Dr. Çiğdem POLATOĞLU, and Prof. Dr. Ayfer AYTUĞ for their guidance in my intellectual, social, and personal growth and valuable expertise. Importantly, I am very fortunate to have Burcu Nimet DUMLU and Mehmet Ali SARIKAYA as my co-authors, who provided valuable advice and support for conducting such significant research.
Above all, I wish to express my deepest thanks and love to my spouse, Yiğit KARAKAŞ, and my lovely daughter İzgi KARAKAŞ for their continuous support and unconditional love, and my parents, Güler ERENOĞLU and Kemal ERENOĞLU for always being there for me and their unwavering belief in me and my work. I am genuinely grateful to have such a wonderful family.

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ABBREVIATIONS

AR : Augmented Reality
CA : Cognitive Architecture
EEG : Electroencephalography
EMG : Electromyography
ERPs : Event-related Brain Potentials
fMRI : Functional Magnetic Resonance Imaging
GPS : Global Positioning System
GSR : Galvanic Skin Response
HRV : Heart Rate Variability
MEGs : Magnetoencephalograms
PET : Positron Emission Tomography
SAM : Self-Assessment Manikin
VR : Virtual Reality

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AN ARCHITECTURAL RESEARCH FRAMEWORK FOR THE NEUROSCIENCE OF HUMAN EXPERIENCE

SUMMARY

The relationship between architecture and neuroscience is an ever-evolving research field forcing the architecture community to explore new theoretical, methodological, and practical approaches. The developments in neuroscience and cognitive sciences and the expanding knowledge of the human brain primarily contribute to understanding human experience and the experiential use of an environmental setting. As an architect, Albright (2020) asked what architects can do with this new knowledge of brain function, and I furthered the question by asking how architects can study with this new knowledge of brain function. Accordingly, the twofold aim of the dissertation is determined as 1) to investigate the neuroscience approach in architecture with an emphasis on the neuroscience of human experience and 2) to develop an architectural research framework for the neuroscience of human experience. With this aim in mind, multiple objectives are produced: 1) developing an overarching conceptual framework for the neuroscience approach in architecture, including elaborating theoretical discourses, methodological approaches, and practical implementations, and 2) building new knowledge on the neuroscience of human experience in architecture. To achieve the aim and objectives of the thesis, an integrated thesis is conducted, consisting of three independent research based on published papers along with introductory and concluding chapters. Each published research paper has its own method while the thesis has a methodological technique to link them into a cohesive conclusion, which is developing an architectural research framework for the neuroscience of human experience. The research papers are examined iteratively to construe insights for developing an architectural research framework for the neuroscience of human experience. Eventually, the method of the thesis relies upon the literature search of developing an architectural research framework and the knowledge gained from the three research papers.

The first paper identified the state of the art within the research field by systematically examining the existing literature, including theoretical and experimental studies. The conceptual framework of the neuroscience approach in architecture was established, prioritizing the influence of the built environment on human experience. Furthermore, the concepts revealed from the literature and the current methodological approaches applied to studying human experience through the neuroscience approach in architecture were extracted and categorized. Lastly, the potentials, challenges, and gaps were revealed.

The second paper examined the research concepts that co-exist with the neuroscience approach in architecture. It was aimed to build new knowledge for the neuroscience of human experience based on the individuals' insights. A case study research strategy was applied to develop an empirical inquiry for investigating the new conceptualizations based on human evolutionary cognitive tendencies, biophilia,

bilateral symmetry, mirror neurons, pareidolia, proxemics, thigmotaxis, curvilinearity, and rectilinearity. In the scope of the study, the human experience was examined as individual human self, interpersonal human being, and through human-built environment interactions and human-nature interactions at self-reflective and observational levels. Such an approach to studying human experience contributed to new theoretical and methodological perspectives in architecture. Theoretically, it expanded the available knowledge on the theory of human experience, reading the city studies, neuro-architecture, and cognitive architecture study fields. Methodologically, the subject of the traditional architectural research methods was shifted from the environmental features to a human being experiencing an environment. The findings indicated that individuals experience their environments through shared behavioral patterns, similar to identified human responses by the concepts of human evolutionary cognitive tendencies, whether consciously or unconsciously. Furthermore, the findings showed that people experience an urban setting by keeping other people and the environmental features in mind and regulating their responses accordingly. As the study's final outcome, the shared behavioral patterns were explained and exhibited as written statements converted into urban codes.

The third paper investigated human behavioral and emotional experiences based on human-built environment interactions with a specific interest in urban graffiti displaying fear and pleasure-inducing facial expressions. Lab-based experimental research in a Virtual Reality(VR) environment was conducted to examine the human experience at self-reflective, observational, and psychophysiological levels. The formulated hypotheses were grounded on the impact of urban graffiti's representational features that elicited specified behavioral and emotional fear and pleasure responses. The behavioral and emotional human responses were assessed objectively by measuring physiological variables, Electroencephalography (EEG) signals and subjectively by behavioral variables, systematic behavioral observation, self-report variables, and Self-assessment Manikin (SAM) questionnaire. Additionally, correlational analyses between behavioral and emotional results were performed. The study's findings validated the hypotheses by revealing identified behavioral and emotional fear and pleasure responses that contributed to the understanding of the neuroscience of human experience and provided resulting evidence for the evidence-based and research-based design processes.

Simultaneously, a literature search was conducted to develop an architectural research framework for the neuroscience of human experience, which was onefold of the thesis aim. Additionally, the knowledge gathered from the first two research papers and the planning process of the third paper was examined to further the existing knowledge on developing an architectural research framework. With the knowledge obtained, the draft of the architectural research framework was developed. Finally, the third paper and the architectural research framework for the neuroscience of human experience were finalized with continuous cooperation, interconnection, iteration and knowledge interchange. In conclusion, the third paper became an applied form of the architectural research framework for the neuroscience of human experience.

İNSAN DENEYİMİNİN NÖROBİLİMİ İÇİN BİR MİMARİ ARAŞTIRMA ÇERÇEVESİ

ÖZET

Mimarlık ve nörobilim arasındaki ilişki, mimarlık camiasını yeni teorik, metodolojik ve pratik yaklaşımları keşfetmeye zorlayan ve sürekli gelişen bir araştırma alanıdır. Nörobilim ve bilişsel bilimlerdeki gelişmeler ve insan beyni üzerine üretilen yeni bilgiler, insan deneyimini ve çevresel bir ortamın deneyimsel kullanımını anlamaya önemli katkıda bulunur. Mimari perspektiften bakıldığında,insan beyni ve cevapları hakkında ne kadar bilgi sahibi olabilirsek, insanın ihtiyaçlarını ve doğasını o kadar iyi anlar ve tasarım üretebiliriz. Eberhard (2009) nörobilim çalışmalarının mimarlıktaki rolünü yapılı çevrede insan deneyiminin anlaşılması için bir çerçeve oluşturulması olarak tanımlarken, Albright (2020) insan deneyiminin yapısının ve sebeplerinin anlaşılması için rasyonel ve ampirik bir yaklaşım olarak tanımlar.

Mimarlık ve nörobilim arakesitinde çalışan önemli isimlerden Albright (2020), mimarların bu yeni beyin işlevi bilgisi ile neler yapabileceğini sormuştur, bu tez kapsamında bu soru mimarların bu yeni beyin işlevi bilgisi ile nasıl çalışabileceğini sorarak ilerletilmiştir. Buna göre, tezin amacı iki yönlü olacak şekilde belirlenmiştir; 1) mimarlıkta nörobilim yaklaşımını insan deneyiminin nörobilimi bağlamında araştırmak ve 2) insan deneyiminin nörobilimi için bir mimari araştırma çerçevesi geliştirmek olarak belirlenmiştir. Bu amaç göz önünde bulundurularak birden fazla hedef üretilmiştir; 1) teorik söylemlerin, metodolojik yaklaşımların ve pratik uygulamaların detaylandırılmasını da içeren mimarlıkta nörobilim yaklaşımı için kapsayıcı bir kavramsal çerçeve geliştirmek ve 2) mimarlıkta insan deneyiminin nörobilimi üzerine yeni bilgiler üretmek. Tezin amaç ve hedeflerini gerçekleştirmek için, tez bilimsel yayınlardan hazırlanmıştır. Çeşitli araştırma yöntemleri uygulayan üç bağımsız makale yazılmış ve alanın önde gelen dergilerinde yayınlanmıştır. Tez kapsamında üretilen üç makale bir giriş ve sonuç bölümü ile birlikte sunulmuştur. Araştırma makaleleri, insan deneyiminin nörobilimi için bir mimari araştırma çerçevesi geliştirmeye yönelik içgörüleri yorumlamak için yinelemeli olarak incelenmiştir. Sonuç olarak, tezin yöntemi insan deneyiminin nörobilimi için bir mimari araştırma çerçevesi üretilmesine ilişkin literatür çalışmasına ve üç makaleden elde edilen bilginin birlikte incelenmesine temellendirilmiştir.

Tezin kapsamının belirlenmesinde Arbib (2013)'in mimarlık ve nörobilimi ilişkilendirmek için oluşturduğu üçlü kategorizasyonundan faydalanılmıştır. Arbib (2013), bu ilişkiyi 1) tasarım sürecinin nörobilimi, 2) nöromorfik mimarlık ve 3) mimari deneyiminin nörobilimi olarak sınıfandırmıştır. Bu tezde, üçüncü kategori olan mimari deneyiminin nörobilimi esas alınmıştır ve insan deneyiminin nörobilimi olarak isimlendirilmiştir. Bu kapsamda, insan deneyimi bireysel insan benliği, kişilerarası insan, insan-yapılı çevre etkileşimi ve insan-doğa etkileşimi olarak dörde ayrılarak incelenmiştir. Ayrıca, insan deneyimi özenelden nesnele doğru ilerleyen bir seviyelendirmede, öz-yansıtma, gözlemsel, psikofizyolojik ve nöral olacak şekilde

dörde ayrılmıştır. Tez, tanımlanan amaçlar, yöntem ve kapsam çerçevesinde üretilmiştir.

İlk araştırma makalesinde, araştırma alanının güncel durumunun tespitini yapmak adına mevcut literatür teorik ve deneysel çalışmaları dahil ederek sistematik olarak incelenmiştir. Çalışma kapsamında, mimarlıkta nörobilim yaklaşımının kavramsal çerçevesi, yapılı çevrenin insan deneyimi üzerindeki etkisine öncelik verilerek oluşturulmuştur. Ek olarak, mimarlıkta nörobilim yaklaşımı aracılığıyla insan deneyiminin nörobilimini inceleyebilmek adına literatür incelemesinde ortaya çıkan kavramsal ve güncel yöntemsel yaklaşımlar ortaya konmuş ve kategorize edilmiştir. Son olarak, çalışma alanın potansiyelleri, zorlukları ve eksiklikleri ortaya konulmuştur.

İkinci araştırma makalesinde, mimarlıkta nörobilim yaklaşımı ile eş zamanlı var olan kavramsal yaklaşımları, insan deneyiminin nörobilimi üzerine yeni bilgiler oluşturmak için bireylerin içgörülerine temellendirerek incelenmiştir. İnsanın evrimsel bilişsel eğilimlerine, biyofili, bilateral simetri, ayna nöronlar, pareidolia, proksemi, tigmotaksis, eğrisellik ve doğrusallık, dayalı yeni kavramsallaştırmaları ampirik olarak incelemek üzere vaka araştırma strateji uygulandı. Çalışma kapsamında insan deneyimi, bireysel insan benliği, kişilerarası insan olarak ve insan-yapılı çevre etkileşimleri ve insan-doğa etkileşimleri aracılığıyla öz-yansıtma ve gözlemsel düzeylerde incelenmiştir. İnsan deneyimini incelemeye yönelik böyle bir yaklaşım, mimaride teorik ve yöntemsel yaklaşımlara katkıda bulunmuştur. Teorik olarak, insan deneyimi, kent okuma, nöro-mimarlık ve bilişsel mimarlık çalışma alanlarındaki mevcut bilgiyi geliştirmişir. Yöntemsel olarak, geleneksel mimari araştırma yöntemlerinin öznesi, çevresel özelliklerden, bir çevreyi deneyimleyen insana kaydırılmıştır. Çalışma bulguları, bireylerin, bilinçli ya da bilinçsiz olarak, insanın evrimsel bilişsel eğilimlerine ilişkin kavramlar ile tanımlanan insan tepkilerine benzer şekilde tepkiler verdiğini ve çevrelerini ortak bir davranışsal kalıba uygun olarak deneyimlediklerini göstermiştir. Buna ek olarak çalışma bulguları, insanların bir kentsel çevreyi diğer insanları ve çevresel özellikleri göz önünde bulundurarak ve çevreye tepkilerini buna göre düzenleyerek deneyimlediklerini göstermiştir. Çalışmanın nihai çıktısı olarak, ortak davranış kalıpları yazılı önermeler olarak oluşturulmuş ve kent kodları olarak sunulmuşur.

Üçüncü araştırma makalesinde, insan-yapılı çevre ilişkisine dayalı insan davranışsal ve duygusal deneyimi korku ve memnuniyet uyandıran yüz ifadeleri içeren kentsel grafiti örnekleri üzerinden incelenmiştir. Çalışma, insan deneyimini öz-yansıtma, gözlemsel ve psikofizyolojik düzeylerde inceleyebilmek adına, laboratuvar ortamında bir deneysel araştırma olarak tasarlanmıştır ve çalışma ekibi tarafından oluşturulmuş bir sanal gerçeklik (VR) mekanı kullanılarak uygulanmıştır. Çalışmanın hipotezleri, kentsel grafitinin temsili özelliklerinin belirli davranışsal ve duygusal korku ve memnuniyet tepkilerini ortaya çıkaracağı savına temellendirilerek formüle edilmiştir. Davranışsal ve duygusal insan tepkileri, fizyolojik değişkenlerin (EEG sinyalleri) ölçülmesi ile nesnel olarak, davranışsal (sistematik davranışsal gözlem) ve öz-bildirim (SAM anketi) ile öznel olarak değerlendirilmiştir. Ek olarak, davranışsal ve duygusal değerlendirme sonuçları arasında korelasyon analizi yapılmıştır. Çalışmanın bulguları, tanımlı davranışsal ve duygusal korku ve memnuniyet tepkilerini ortaya çıkararak çalışmanın hipotezlerini doğrulamıştır. Ayrıca, çalışma bulguları, insan deneyiminin nörobilimin anlaşılmasına katkı sağlamakla birlikte, kanıta dayalı tasarım ve araştırmaya dayalı tasarım süreçlerine kanıt niteliğinde bilgi sağlamıştır.

Eş zamanlı olarak, tez kapsamında araştırılan iki amaçtan biri olan, insan deneyiminin nörobilimi için bir mimari araştırma çerçevesi geliştirmek üzere bir literatür çalışması yapılmıştır. Ek olarak, ilk iki araştırma makalesinin tamamlanması ve üçüncü makalenin planlaması sürecinde edinilen bilgiler mimari araştırma çerçevesi geliştirmeye yönelik mevcut bilgileri ilerletmek amacıyla detaylı şekilde incelenmiştir. Elde edilen bilgiler ile taslak bir mimari araştırması çerçevesi üretilmiştir. En sonunda, üçüncü araştırma makalesi ve insan deneyimin nörobilimi için bir mimari araştırma çerçevesi kesintisiz bir işbirliği ve bilgi aktarımı ile eş zamanlı olarak tamamlanmıştır. Üçüncü araştırma makalesi geliştirilen araştırma çerçevesinin uygulamalı bir örneği olmuştur.

Tez kapsamında üretilen mimari araştırma çerçevesi mimarlığın üç temel ögesi olan teori, yöntem ve uygulamayı bir arada değerlendirmiştir. Teori başlığı araştırma paradigması, araştırma alanı, araştırma kavramları, araştırma değişkenleri olacak şekilde dörde ayrılarak; Yöntem başlığı araştırma tasarımı, araştırma stratejisi, araştırma yöntemi olacak şekilde üçe ayrılarak; Pratik başlığı ise operasyonel çıktılar ve araştırma & tasarım işbirliği olarak incelenmiştir.

Sonuç olarak, mimarlık ve nörobilim arasındaki ilişkinin derinlemesine çalışılması ile bu tez, mimarlıkta nörobilim yaklaşımına teorik, yöntemsel ve pratik açılardan geliştiren, insan deneyiminin nörobiliminin anlaşılmasını sağlayan yeni bilgi üretmiştir. Sonucunda ise, insan deneyiminin nörobilimi için bir araştırma çerçevesi oluşturmuştur. Ek olarak, mimarlıkta nörobilim yaklaşımının uygulanması ile üretilen bilginin karmaşıklık ve iç bağlantılılık olarak karakterize edilirken, araştırma süreci işbirliği, değişim, ara bağlantı ve yineleme özelliklerine temellendirilmiştir. Bu şekilde elde edilen bilginin araştırma-temelli, kanıta dayalı, insan merkezli mimari tasarım yaklaşımlarına katkı sağlayarak geliştirceği söylenmiştir.

1. INTRODUCTION

The architectural community has become aware of the significant importance of human experience in architecture and the built environment since the 1960s. The critiques of the Modern Movement based on various disciplinary knowledge had affected the approaches due to understanding the human experience. Then, those approaches were developed into specified study fields. In the 1960s, architectural studies benefited from the behavioral sciences, psychology, and anthropology that established environment and behavior, environmental psychology, and human ecology study fields (Lang, 1987). In the 1980s, phenomenological approaches were added to the studies of human experience that established phenomenological architecture (Mallgrave & Goodman, 2011). Since the 1990s, we have been experiencing a stimulating time of developing science-based approaches in architecture, including bio-informatics, artificial intelligence, virtual realm (Picon & Ponte, 2003), and neuroscience (Eberhard, 2007, 2009a; Pallasmaa et al., n.d.; Zeisel, 2006). Neuroscience and cognitive sciences developments have significantly impacted the systematic understanding of human experience in architecture and the built environment. Neuro-architecture (Edelstein, 2015; Frascari, 2012) and cognitive architecture (Hauptmann et al., 2010; Sussman & Hollander, 2015) study fields have emerged in the light of those significant impacts with a specified interest in the human brain, mind, and psyche.

The technical and theoretical developments in understanding the human brain and mind and the new experimental paradigms in scientific knowledge-building have created the need for revolutionary consideration of architecture's theory, methodology, and practice. According to Eberhard (2009), a paradigm shift occurred in the way of thinking and producing architecture and neuroscience. This paradigmatic change resulted from the simultaneous crisis of architecture and neuroscience that was fundamentally based on the disciplines being inapproachable for their subjects, human beings. Based on the knowledge derived from neuroscience and cognitive sciences and applied to architecture, this paradigm shift has significantly changed the current

theoretical debates and methodological and practical approaches in architecture and neuroscience, bringing the human experience to the center. Above all, architects and neuroscientists have become more open-minded to studying in a multidisciplinary manner to enhance the human experience in architecture and the built environment.

The intersected area is novel to architects and neuroscientists and needs systematic mediation. From the perspective of architectural studies, the more we learn about the human brain and human responses, the more we can understand and design for human needs and nature. From the perspective of neuroscience studies, as Gage explained, changes in the environment change the brain and, therefore, can change our behavior due to the brain's neuroplasticity (Eberhard, 2009b). In Brain Landscape, Eberhard (2009) explained using neuroscience for architecture as establishing a framework for understanding how people experience the built environment. Albright (2020) also defined the role of neuroscience in architectural studies as simply a rational and empirical approach to understanding the structure and causes of human experience and asked *what architects can do with this new knowledge of brain function.* Furthering the question, we asked *how architects can work with this new knowledge of brain function.*

1.1 Research Background for Developing an Architectural Research Framework for Neuroscience of Human Experience

The neuroscience approach in architecture has the power to develop alternative knowledge claims considering ontological and epistemological interpretations. This significant potential proposes answers for what and how questions occurred in creating the relationship between architecture and neuroscience. However, the link is still in its infancy requiring more concentration on multidisciplinary interactions to create meaningful relations for theoretical and experimental studies and practical implementations through a coherent research framework.

The neuroscience approach in architecture is an umbrella term referring to all the aspects of the relationship between architecture and neuroscience. However, this dissertation studies and discusses the neuroscience of human experience. Therefore, in the scope of the study, an architectural research framework for the neuroscience of human experience is aimed to be developed.

The literature on developing a research framework for the neuroscience approach in architecture has appeared fragmentedly. A pioneering study was designed by Zeisel (2006), looking from the viewpoint of environment and behavior studies. Zeisel (2006) systematically added neuroscience knowledge to the environment and behavior knowledge. He proposed the E(environment) – B(behavior) – N(neuroscience) paradigm that addressed the relationship between people's brains' neurological and biological function and the way they behave and interact with the built environment. The E-B-N paradigm combines neuroscience research tools and concepts with environment and behavior studies and extends the available methodological approaches. Another study was provided by Dougherty & Arbib (2013b) to outline a framework based on the papers presented at the Academy of Neuroscience for Architecture (ANFA) 2012 for the benefit of the architectural community. The study briefly revealed common architectural design strategies based on neuroscience studies to apply through architectural and environmental design. Then, Robinson (2015) searched for a philosophical framework based on Dewey's pragmatism to confront the lack of identified roles, borders, research approaches, and terminology that aimed to propose an initial regulation for this disjointly growing literature. More recently, Coburn (2017) developed an initial framework based on Chatterjee & Vartanian (2013)s' aesthetic triad, which consisted of sensorimotor, knowledge-meaning and emotion-valuation systems. The framework was based on the neuroaesthetic literature to suggest insights for the neuro-architecture study field. As seen, the idea of developing a framework for the neuroscience approach in architecture has not been occurring in a successive way leading to a coherent architectural research framework. Therefore, this thesis aims to provide an architectural research framework for the neuroscience approach in architecture based on the neuroscience of human experience through a holistic and systematic approach.

As a general tendency of the architectural community, architectural research frameworks primarily discuss the theory and methodology, discarding the practical outputs. On the contrary, research developed through the neuroscience approach in architecture diversifies the ways of learning from research and provides factual findings and evidence for architectural, urban, and landscape design practices. Thus, the neuroscience approach in architecture changes traditional architectural research

tendencies by crossing boundaries and integrating the three pillars of architectural research: theory, methodology, and practice.

The terminology for writing a research framework varies in the literature. Creswell (2003) categorized the research framework with three elements of inquiry which are knowledge claim (ontology and epistemology), strategy (quantitative, qualitative, and mixed methods approach), and method (methods of data collection and analysis). In the last edition, Creswell (2014) modified the three key terms covering the overall research from the broadest philosophical assumption to the detailed methods as research approaches, research designs, and research methods. Groat and Wang used the classification of the system of inquiry (SoI), school of thought (SoT), strategy (S), and tactics (T) as the conceptual research framework. As seen, those architectural research frameworks set aside the practical implications of the research outcomes. On the other hand, Zeisel (2006) identified "doing research" as developing concepts, formulating hypotheses, and empirical testing while accompanying it with research and design cooperation. He formulates the E-B-N paradigm, prioritizing research and design relationships and considering design performance criteria with the formulating hypothesis. That kind of research approach naturally contributes to architectural practice. Therefore, the thesis subsumes theory, methodology, and practice as the primary elements of the architectural research framework.

1.2 Purpose of the Thesis

The twofold aim of the dissertation is determined as 1) to investigate the neuroscience approach in architecture with an emphasis on the neuroscience of human experience and 2) to develop an architectural research framework for the neuroscience of human experience. With this aim in mind, multiple objectives are produced; 1) developing an overarching conceptual framework for the neuroscience approach in architecture, including the elaboration of theoretical discourses, methodological approaches, and practical implementations and 2) building new knowledge on the neuroscience of human experience in architecture. To illuminate this uncharted area, a complex research design is developed. One way to explore the neuroscience approach in architecture is to apply the existing knowledge to architectural research problems through multiple formulations. Accordingly, the thesis produces a multidisciplinary, multidimensional, and multimodal perspective employing architectural, neuroscience,

and cognitive knowledge that exceeds the limitations of traditional research approaches in architecture and the built environment. To do so, the neuroscience of human experience is considered as a vertex to develop serial coherent research papers.

1.3 Scope of the Thesis

Inherent within neuroscience is tremendous potential to link architecture and the built environment to the human experience in architecture. Arbib (2013) categorizes the ways of relating architecture and neuroscience into three; (1) the neuroscience of the design process, which examines the architect's brains, (2) the neuromorphic architecture, which examines the brains of buildings, (3) the neuroscience of the experience of architecture, examines the brains of individuals experiencing a built environment. In the scope of the thesis, the third link, which is mentioned as the neuroscience of human experience in architecture, is studied profoundly with a focus on the knowledge of the human brain and mind. Neuroscience of human experience investigates the human experience as a holistic matter of fact, concerning it as an individual human self, interpersonal human being, and through human-built environment interactions and human-nature interactions within the lens of neuro-architecture and cognitive architecture studies.

1.4 Method of the Thesis

The thesis' research motivation is developing an architectural research based on the investigation of neuroscience approach in architecture emphasizing the human experience through multidisciplinary(architecture, environment-behaviour, neuroscience, cognitive sciences, informatics), multi-method(qualitative, quantitative, multi/mixed method), multidimensional(behavioral, emotional, cognitive, sensational) and multimodal(physiological, neuro-imaging, observational, self-report) approaches.

Following this motivation, the thesis is developed as an intagrated thesis, which consists of three independent works based on published papers accompanied by introductory and concluding chapters. Each published research paper has its own method while the thesis has a methodological technique to link the research papers

into a cohesive conclusion, which is developing an architectural research framework for the neuroscience of human experience.

The method of the first paper is a systematic literature review while the second paper is a case study. Additionally, the method of the third paper is multi-method approach applying qualitative and quantitative techniques and developed as a lab-based experimental research. Finally, the method of thesis is based on the criritcal examination of the literature search on developing a research framework for the neuroscience approach in architecture and the knowledge gained from the three research papers.

The method of the thesis has occurred in an iterative way that started with a simple question on how architectural research could be developed with the knowledge of brain functioning. This simple question led the thesis research on the current theoretical and methodological approaches and to find the logic behind conducting research applying brain knowledge.

Firstly, the first and second research papers were conducted and the literature of existing research framework for the neuroscience approach in architecture was studied. The first and second papers induced the importance of conducting experimental research, which required approaching architectural research problems from a positivist perspective. Within the insights from research papers and the review, the draft of architectural research framework and third research paper was prepared as shown in Figure 1.1.

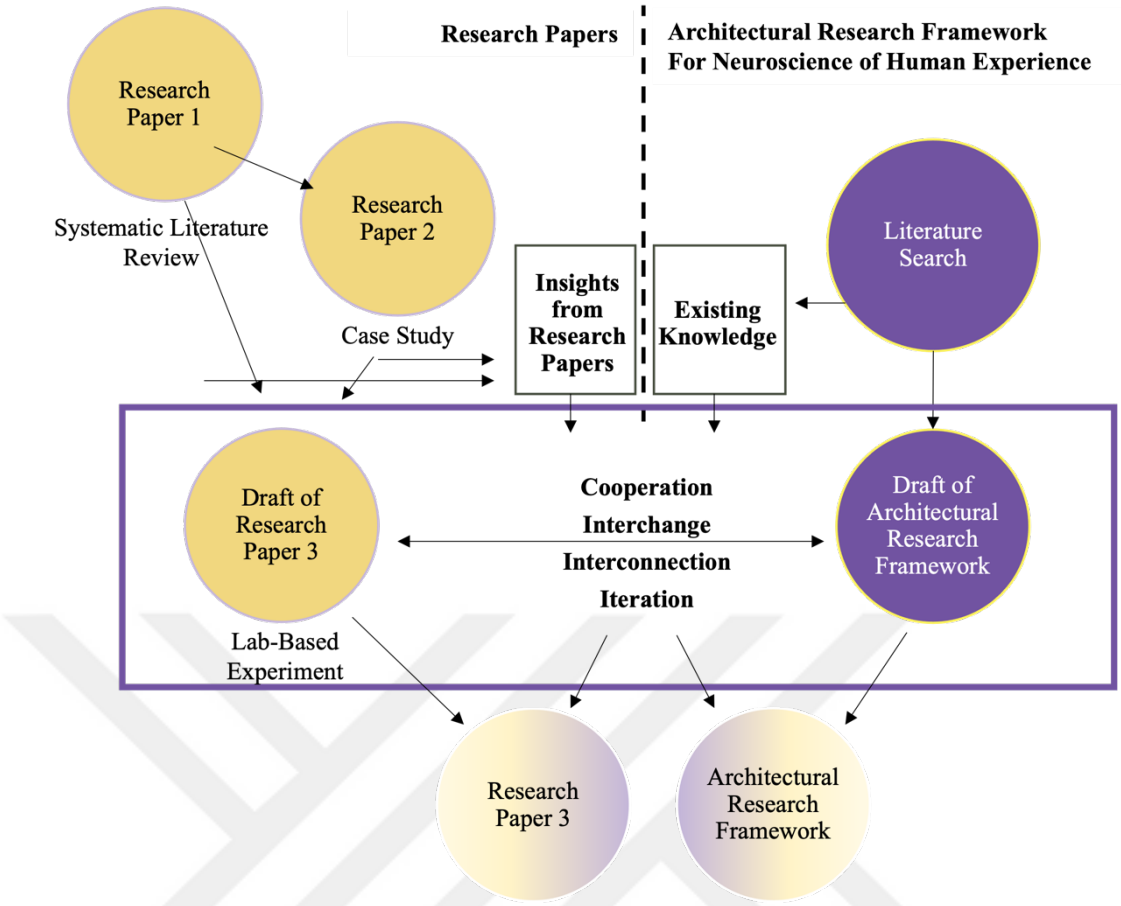


Figure 1.1 : The method of the thesis.

Secondly, the draft of architectural research framework and third research paper was examined in detail applying cooperation, knowledge interchange, interconnection and iteration in between the studies.

Finally, the knowledge transformation between the research papers and the study of developing an architectural research framework was concluded with the final version of the architectural research framework for the neuroscience of human experience and the third paper.

1.5 Significance and Unique Aspect of the Thesis

Considering that the neuroscience approach in architecture is an emerging field that requires in-depth research, the thesis research design of the thesis is novel, pioneering, entrepreneurial and timely.

Investigating the neuroscience approach in architecture with an emphasis on the neuroscience of human experience has a significant impact on creating an awareness

of the influence of architecture and built environment on human body-brain systems looking from a scientific standpoint. Additionally, the thesis contributes expanding the knowledge on the responses of brain and mind, examining the environmental attributes and their impacts on the human brain, mind, and psyche, understanding how people perceive and interact with the world around them, understanding the sensory, cognitive, behavioral and emotional dimensions of human experience, creating a better-built environment within the evidence-based, and research-based data, enhancing the daily experience of individuals.

Furthermore, developing an architectural research framework is significantly essential to propose answers for what and how questions (epistemological and ontological) occur in architectural research. An architectural research framework contributes to define the roles, approaches, and terminology, to develop a holistic, systematic, and coherent approach, to provide systematic knowledge for future studies, to create more integrated and concentrated perspectives for further studies, to create evidence-based and research-based knowledge concerning the human experience in architecture, to advance the scientific evidence for design process and to provide factual findings for the legislators and the regulators of the design disciplines. Therefore, the thesis is vital for enlightening the newly developed theoretical and methodological approaches and the practical implementations of the neuroscience approach in architecture.

The thesis provides valuable insights into the neuroscience of human experience at different levels by applying qualitative, quantitative, and multi-method approaches. At psychophysiological levels, the knowledge of human experience was gathered by employing technological advancements in psychophysiological measurements and virtual reality technologies. Such an approach offers an alternative way of developing an architectural research design by adding the neuroscience approach to the current perspectives. Additionally, human experience at observable and self-reflective levels was studied using the traditional environment and behavior research methods, including behavioral observation and self-report tools. Eventually, the study provided objective and subjective knowledge of the neuroscience of human experience.

Consequently, a detailed critical discussion was developed to generate new knowledge in the study field, considering the findings of three papers and the experiences of the overall process. The output of the study can be insightful for whom has a particular interest in understanding human experience as a holistic fact and related to any of those

disciplines; architecture, neuroscience, behavioral and cognitive sciences, and informatics.

1.6 Research Framework

This thesis intends to explore an elaboration of theoretical, methodological, and practical approaches applied in studying the relationship between architecture and neuroscience, prioritizing the neuroscience of human experience. Three independent studies were developed within a dependent research framework. The studies have the following aims, research questions, hypotheses, and methodologies shown in Table 1.1.

Table 1.1 : The three papers.

	Exploring the influence of the built environment on the human experience through a neuroscience approach: A systematic review (Chapter 2)	
1	**Aim**	To explain the influence of the built environment on the human experience through the neuroscience approach in architecture by examining the conceptualizations in the field.
	RQ	**1)** What are the key theories and methodologies leading to the development of neuroscience and architecture studies in the literature? **2)** What are the developing and emerging concepts in theoretical and experimental studies that explain the influence of the built environment on human experience by using approaches from neuroscience?
	M	Qualitative Research – Systematic Literature Review
	Minding the city: A case study on the new conceptualizations of human experience in the built environment (Chapter 3)	
2	**Aim**	To mind the city by taking the information gathered through the senses and processed in the human brain as the primary concern in understanding the human experience in the built environment through the investigation of conceptualizations based on human evolutionary cognitive tendencies; biophilia, bilateral symmetry, mirror neurons, pareidolia, proxemics, thigmotaxis, curvilinearity and rectilinearity.
	RQ	How would the human experience be understood through the new conceptualizations based on human evolutionary cognitive tendencies in a real urban setting?
	M	Qualitative Research – Case Study
	The impact of urban graffiti with facial expressions on human behavioral and emotional responses in a VR environment (Chapter 4)	
3	**Aim**	To investigate the human behavioral and emotional experiences based on human-built environment interaction with a specific interest in urban graffiti displaying fear and pleasure-inducing facial expressions.
	RQ	**1)** Which behavioral responses occur upon encountering urban graffiti displaying fear and pleasure-inducing facial expressions? **2)** Which emotional responses occur upon encountering urban graffiti displaying fear and pleasure-inducing facial expressions?
	H	**H1:** Urban graffiti's representational features impact human behavioral responses. **H1-1:** The urban graffiti displaying fear-inducing facial expressions elicit a behavioral fear response. **H1-2:** The urban graffiti displaying pleasure-inducing facial expressions elicit a behavioral pleasure response. **H2:** Urban graffiti's representational features impact human emotional responses. **H2-1:** The urban graffiti displaying fear-inducing facial expressions elicit an emotional fear response. **H2-2:** The urban graffiti displaying pleasure-inducing facial expressions elicit an emotional pleasure response.
	M	Multi-Method Approach – Experimental Research (Lab-based)

The research framework of the thesis was based on the detailed study of the neuroscience approach in architecture emphasizing the neuroscience of human experience within the defined aims and objectives of the thesis. Therefore, the papers

were designed in a particular order to manage the available knowledge in the research area. Additionally, the operational processes for the papers' research design were taken into consideration.

The first paper was conducted as a systematic literature review to identify the state of the art within the research field. The paper's primary aim was to systematically examine the existing literature to reveal the established relations for developing a conceptual framework of the neuroscience approach in architecture. Followingly, it aimed to explore the influence of the built environment on human experience by using the neuroscience approach. Lastly, the paper aims to introduce the available literature by examining theoretical and experimental studies to identify the path leading to such a novel study field. The outcome of the first paper was 1) the extraction and categorization of the developing and emerging concepts concerning the human experience in the study field, 2) the classification of currently used methodological approaches (from traditional to newly developed), including architectural, neuroscience, behavioral and cognitive research methods, and techniques. The paper's findings contributed to generating the conceptual framework of the neuroscience approach in architecture. Additionally, the paper's results revealed the potential, challenges, and gaps in the field regarding the associations between theoretical studies and their implications in experimental studies.

The first paper was regarded as the primary study, shaping the theoretical and methodological approaches and the expected practical outputs, applied in the second and the third paper. The second and third papers aimed to cross the borders of architectural theory and method with a significant impact on architectural practice. The second paper applied traditional architectural research methods to the research concepts that occurred with the neuroscience approach in architecture. In contrast, the third paper studied an ongoing architectural problem using new methods derived from neuroscience studies. As a result, the second paper brought new perspectives to understanding the human experience in the built environment from individual' insights, while the third paper offered new and objective solutions for an architectural problem in enhancing the human experience.

The conceptual framework established in the first paper was applied to the second paper as the study's theoretical framework. The study intended to mind the city by

taking the information gathered through the senses and processed in the human brain as the primary concern in understanding the human experience in the built environment. The paper investigated the conceptualizations based on human evolutionary cognitive tendencies, biophilia, bilateral symmetry, mirror neurons, pareidolia, proxemics, thigmotaxis, curvilinearity and rectilinearity. The study was designed as qualitative research employing a case study. Observational measurements, mapping techniques, and the declaration of the participants' own experiences were used as research techniques and tools. The case study research strategy was used to develop an explanatory and exploratory empirical inquiry for in situ situations studied through fieldwork. The fieldwork of the main study produced for the Eastern Mediterranean University 9th International Design Week with the name "Minding the City / Famagusta: Bring your brain into the built environment." The final outputs of the study were cognitive maps, digital drawings, and generated urban codes developed separately for each conceptualization. The urban codes were presented and discussed within the related literature, and in conclusion, an overall interpretation was developed.

The third paper mainly studied the potentials, gaps, and challenges defined in the first paper by applying neuroscience research techniques combined with traditional architecture research techniques. Following the findings of first paper, an ongoing architectural research problem was studied to address one of the challenges of the study field, formulating testable hypothesses in an experimental study. The third paper primarily investigated the human behavioral and emotional experiences based on human-built environment interaction with a specific interest in urban graffiti displaying fear and pleasure-inducing facial expressions. The research hypotheses were grounded on the impact of the representational features of urban graffiti on the human behavioral and emotional experiences that elicit specified fear and pleasure responses. The research design was developed as a lab-based experimental study. A multi-method approach was applied, including objective and subjective data collection and processing techniques and statistical and correlational analysis. We combined neuroscience methods with the self-reports (Self-assessment Manikin [SAM] questionnaire) and the systematic observation of human behaviors. As the experimental medium, we employed Virtual Reality (VR) technologies. The research equipment included a mobile electroencephalogram (EEG) device embedded in the VR headset, a Looxid Link device, and a VR headset. Objective and subjective data

were obtained, including EEG signals, screen recordings of the VR experiments, and SAM questionnaire. In analyzing and synthesizing the data, observational, statistical, and correlational tools were used. The findings and results were interpreted and discussed within the related literature, and the limitations and future works were presented.

1.7 Organization of the Thesis

This thesis is organized into six main parts in the flow of three published papers:

Chapter 1 provides a brief introduction, including the general purpose, scope, the research framework that introduced the linkage between the papers, and the organization of the thesis;

Chapter 2 is the first paper, "Exploring the influence of the built environment on human experience through a neuroscience approach: A systematic review". The paper was published in Frontiers of Architectural Research in March 2020.

Chapter 3 is the second paper, "Minding the city: A case study on the new conceptualizations of human experience in the built environment". The paper was published in A|Z ITU Journal of the Faculty of Architecture in March 2023.

Chapter 4 is the third paper, “The impact of urban graffiti with facial expressions on human behavioural and emotional responses in a VR environment”. The paper was published in Archnet-IJAR: International Journal of Architectural Research in August 2023.

Chapter 5 provides discussions and implications. An overall discussion was developed regarding the defined aims and objectives of the thesis, and the implications of the findings were revealed;

Chapter 6 provides a conclusion and future works.

2. EXPLORING THE INFLUENCE OF THE BUILT ENVIRONMENT ON HUMAN EXPERIENCE THROUGH A NEUROSCIENCE APPROACH: A SYSTEMATIC REVIEW[1]

2.1 Introduction

The interaction between humans and the built environment has a significant potential for knowledge creation in environmental design disciplines. Knowledge derived from human responses to the built environment can be utilized in design decisions to create an improved fit and further harmonious relationship between humans and the built (Horayangkura, 2012; Lang, 1987). That is, the more we understand human responses to the built environment, the better we can design for these responses. Through a retrospective view of architectural development and urban theory, research on humanebuilt environment interaction has become further influential since the decline of Modernism in the 1960s. At that time, environment and behavior studies were concerned with the mutual interaction of people and the built environment (Lang, 1987; Rapoport, 1977) and used traditional research techniques, such as surveys and observations, to obtain research evidence. Later, developments in science and technology, including bio-informatics, artificial intelligence, virtual realms (Picon & Ponte, 2003), and neuroscience (Eberhard, 2007; S Robinson & Pallasmaa, 2015; Zeisel, 2006), and in interdisciplinary collaborations between these fields led to the emergence of new perspectives, data-collecting devices, and measurement techniques, which eventually expanded the knowledge on humanebuilt environment interaction. These developments also led to the research on the interaction between neuroscience and architecture. This constantly evolving field of study can be regarded as a continuation of environment and behavior studies and is likely to become the domain of a new generation of applied social and behavioral scientists, engineers, and architects within the next few decades of the twenty-first century (Eberhard, 2009).

[1]This chapter is based on the following publication: Karakas, T. and Yildiz, D. (2020), "Exploring the influence of the built environment on human experience through a neuroscience approach: A systematic review." Frontiers of Architectural Research, Higher Education Press Limited Company, Vol. 9 No. 1, pp. 236–247.

Findings from neuroscience have recently been utilized in research studies to improve and deepen the knowledge of human experience in the built environment. Linking the study of architecture and the built environment to the human experience inherent within neuroscience has tremendous potential. Increasing interest in the potential of

the relationship between neuroscience and architecture has created a necessity of establishing a common theoretical and methodological ground on which to conduct interdisciplinary studies. Given this growing literature, this common ground has been established through the developing and emerging concepts based on the knowledge of neuroscience and architecture. The present review aims to reveal the most recent developments in this new field of study and its theoretical and methodological

potential by prioritizing the conceptualization of the field through the lens of neuroscience. This undertaking enables us to explore human experience in the built environment thoroughly. Therefore, this review deeply and systematically analyzes and synthesizes the existing literature to find the developing and emerging concepts that have appeared at the intersection of neuroscience and architecture alongside improvements in methodology.

In the current literature, despite the growing body of theoretical and experimental studies, few works have systematically reviewed the literature (Dougherty & Arbib, 2013; Giuliani & Scopelliti, 2009). Many of the reviews have investigated the subject from different angles in individual, fragmented, and diverse ways. However, a systematic and holistic review of the literature, addressing emerging concepts in the field to identify the common ground between neuroscience and architecture, is missing. To rectify this omission, the present work is conducted as a systematic qualitative review and concerned with analyzing and synthesizing the developing and emerging concepts that have appeared in light of the ever-evolving literature. The review not only frames the overall state of the intersection between the two fields but also helps academics place their research problems within the latest research directions, thereby showing possible paths for future studies. The review initially examines the theories that have paved the way for the exploration of human experience in the built environment by using approaches based on neuroscience. Then, the interactions between neuroscience and architecture are introduced as a new paradigmatic change. Subsequently, new fields of study and methodological approaches are explained to understand the current state of interdisciplinary studies in

neuroscience and architecture. Finally, theoretical and experimental studies are examined separately to extract the developing and emerging concepts at the intersection of these fields, which explain the influence of the built environment on human experience by using approaches from neuroscience. Theoretical and

experimental studies based on the developing and emerging concepts are compared to understand the associations between the theory and its applications in experimental studies. In addition, the types of outcomes extracted from the experimental studies are categorized as developing and emerging concepts, human experience, built environment features, and measurement techniques to examine human experience in its entirety. The study concludes with a discussion about the possible means of understanding the influence of the built environment on human experience by using approaches grounded in neuroscience and their potential for directing future developments.

2.2 Developing a Systematic Review

2.2.1 Review questions

Two research questions were asked during the review.

1) What are the key theories and methodologies leading to the development of neuroscience and architecture studies in the literature?

2) What are the developing and emerging concepts in theoretical and experimental studies that explain the influence of the built environment on human experience by using approaches from neuroscience?

Question 1 is designed to understand the basis of the current situation by reviewing the key resources that have led to the development of interdisciplinary studies in neuroscience and architecture. Question 2 is the primary research question in this study. We conducted a systematic qualitative review to identify the developing and emerging concepts in neuroscience and architecture, which may inform the general conceptual direction for future studies.

2.2.2 Search strategy and selection criteria

A sensitive search of sources published in English since 2000 was conducted using the keywords “neuroscience and architecture,” “neuroscience for architecture,” “neuro-architecture,” and “cognitive architecture.” Each keyword search was combined with the keyword “built environment.” The search aimed to capture a comprehensive sample of the literature relevant to the research questions. Google Scholar, Web of Science, Scopus, and Ebsco databases were searched to maximize coverage. Google

Scholar supplied a comprehensive search result, and categorizing the sources in accordance with the citation index or influence factors did not attain the goal because of the multidisciplinary and nascent nature of the question.

Articles and books were included, whereas conference papers, proceedings, reports, and dissertations were excluded. Duplicates were avoided by using Mendeley software. The studies were grouped as books, book chapters, and articles. Books returned by all keyword searches were selected. Articles returned by the keyword searches were selected and grouped on the basis of their theoretical, review, and experimental content focusing on the influence of the built environment on human experience. They were selected on the basis of titles, abstracts, keywords, and questions or hypotheses.

2.3 Theories on the Built Environment that are Precursors to Neuroscience Approach: A Brief History

Theories of the built environment that led to collaborations between architecture and neuroscience first appeared in the post-1960 period. They arose in environment and behavior studies, which were stimulated by newly voiced criticisms of the inhumane aspects of the built environment. According to Jacobs (2002), the problem of modernist design principles lies in that period’s focus on how things look and the search for a pleasing aesthetic as the primary purpose of design. She went on to assert that this type of single-minded purpose ignores the sort of innate, functioning order of design. Concurrently with Jacobs, a diverse group that called itself the “Situationist International” began to coalesce in Europe under the flag of rejection of modernist urbanism. Proponents of this approach created a series of works to raise public awareness about the importance of participating in everyday life in cities. Henri

Lefebvre, who was also another influential figure of this period, explained individual alienation as losing one's essential being as a result of becoming fragmented and disassociated with everyday life (Hays, 1998). According to Heynen (1999), the Situationist movement and Lefebvre's claims share common ground in their assertions that the deficiencies inherent in contemporary urban theories led to human suffering and caused the alienation of people faced with the types of problems encountered in "simple" everyday lives.

An empirical study of human experience associated with perception, cognition, and memory first appeared in the literature in Lynch's studies of a city. He explained the importance of the perceptual and sensory experience of the city by revealing its mental image through the eyes of its citizens. Lynch (1960), discussed many concepts referencing psychological knowledge, such as wayfinding, orientation, navigation, size, time, complexity, and the idea of identity/identification, recognition, and

structure, spatial or pattern relations of the object to the observer, all of which he studied under his theory of legibility. From his work, we can infer that Lynch also had concerns about the brain per se, as evidenced in his discussions regarding the human brain's capacity to adapt to surroundings.

From the perspective of positivist theory applied to the built environment, Lang (1987) voiced criticisms of the inhumane conditions of the modern era by dividing these critics into three phases. The first phase started with the attempts of Team X who disapproved of the applied design principles of the modern movement because of its mindnumbing, hygienic aesthetic, and inhumane conditions of cities that make people feel like nobodies in nowhere. The ideas proposed by Jacobs (2002) were defined as the second phase, whereas the third phase grew from developments in behavioral sciences that enabled the identification of human experience in the built environment. The third phase, which introduced developments in environment and behavior studies along with the creation of a positivist theoretical base for design disciplines, introduced the importance of human perception, senses, emotion, and ideas related to the sense of place and memory.

Eberhard (2009) defined environment and behavior studies as the precursors of neuroscience studies that tackled many diverse issues: the changing role of professionals, the destruction of normative theories, the importance of human nature in the design process, and the identification of user experience in the built

environment. The study of the relationships between the environment and behavior that regards the environment as a context for human beings' behaviors and responses has been investigated within many different disciplines, including psychology, anthropology, geography, social theory, urban design, urban planning, and architecture.

Environment and behavior studies have focused on understanding how people interact with their environments and how these mutual reactions are established in varied contexts. As examples, we can cite Sommer's (1969) idea of personal space, Hall's (1969) idea of hidden dimensions, and Gans's (1982) studies on the urban villager. In 1970, a group of psychologists published a text called "Environmental Psychology" (Proshansky et al., 1970). Between the 1970s and 1990s, this study area was dominated by urban design, planning, and architecture, but after the 1990s, it began to focus more on psychology by articulating critical debates that regarded the environment as a

secondary component in human psychology (Gieseking, 2014). Currently, the relationships between human beings and the built environment have started to regain priority; the emergence of this new field is primarily due to developments in neuroscience and cognitive sciences that enabled researchers to understand the effect of the built environment on the human brain via evidence-based data.

Farling (2015) expressed how neuroscience extends the field of environment and behavior relations and stated that although environmental psychologists inform us about what behavior is occurring, neuroscientists go further because they can tell us why the behavior is occurring. Similarly, Ellard (2015) explained the major role of the human brain in experiencing the built environment by stating that wherever we go, our nervous system and minds are constantly being bombarded by messages in relation to what we are experiencing. Human experience in architecture and the built environment has been studied intensively since the 1960s, but the role played by the human brain in this experience has only been recently introduced to the field in the beginning of the 2000s.

2.4 Neuroscience and Architecture

Developments in neuroscience have allowed us to improve and deepen the knowledge of human responses and created a new way of thinking about current theories in the

field of architecture and the built environment. The idea of bringing the human brain into the built environment has been introduced in theoretical and methodological approaches, which have created a paradigmatic change (Eberhard, 2009). This paradigmatic change requires new perspectives to relate the human brain to the built environment. The human brain can be examined on the basis of the individual standpoints of researchers. Arbib (2013) categorized the relationship between neuroscience and architecture into three parts: (1) the neuroscience of the design process, which examines architects' brains; (2) the neuromorphic architecture, which examines the brains of buildings; and (3) the neuroscience of the architectural experience, which examines the brains of individuals experiencing a built environment. In the scope of this study, only the concepts derived from the examination of individuals' brains in terms of how they respond to the existing built environment are studied to provide a focus for the review.

2.4.1 New fields of study in architecture that have emerged at the intersection

Examining human experience in the built environment through a neuroscientific approach requires a clarification of differences among and overlaps between some specific terms, such as neuroscience, cognitive science, neuroarchitecture, and cognitive architecture, before exploring the theoretical underpinnings of this intersection. The broadest cluster is cognitive science, which is related to mind processes and refers to many types of thinking, including perception, learning, problem-solving, decision making, reasoning, and emotional experiece (Thagard, 2013). Neuroscience is part of cognitive sciences and studies the nervous system with a specific focus on the human brain.

From the perspective of the architectural community, we can see that the twenty-first century has ushered in some new trends that have been arisen from the intersection of neuroscience and architecture — trends which can be grouped into new movements as cognitive architecture (Hauptmann & Neidich, 2010; Sussman & Hollander, 2015) and neuro-architecture (Edelstein, 2015; Frascari, 2012). Since cognitive science is an inherent part of neuroscience, neuro-architecture, and cognitive architecture, it will not be the focus of this work; rather we will refer to the terms of neuroscience, cognitive architecture, and neuro-architecture. Cognitive architecture and neuro-architecture have emerged in light of these new approaches. Both of them focus on the influence of the built environment on the human brain and its responses to the built environment.

The most important contribution of the collaboration between neuroscience and architecture is creating an understanding not only of the conscious but also the subconscious and unconscious tendencies of human beings which are innate, idiosyncratic, and inherited from our evolutionary past.

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The term cognitive architecture was first used by Deborah Hauptman in 2010. Hauptmann and Neidich (2010) defined cognitive architecture as the idea of mind in information and communication technologies. She explained the evolving modalities of the new era by expanding such ideas from biopolitics to noo-politics, which is hypothesized as an exerted power over the life of the mind, including perception, attention, and memory. Sussman and Hollander (2015) explored how research in psychology, cognitive science, and neuroscience can enhance our understanding of the influence of the built environment on human experience. On the basis of this collaboration, the authors introduced five main principles: 1) edges matter, 2) pattern matters, 3) shapes carry weight, 4) storytelling is key for we are wired for narrative, and 5) nature is our context. Within these principles, they outlined the hidden aspects of human nature.

Neuro-architecture, which is based on the interactions of the neuronal activities of the brain and the built environment, is ranked as a nascent field that combines neuroscience, environmental psychology, and architecture. Neuro-architecture seems

mostly similar to cognitive architecture at first glance, but it is remarkably concerned with the form and plasticity of things. As Edelstein (2015a) argued, the term neuro-architecture has long been used to denote the brain's form and function, which is the origin of the new field. Architects have increasingly adopted this term to describe a new field of study that explores how the form of architecture may further serve human functions and generate delight.

2.4.2 How the brain works

The human brain is a complex phenomenon that is difficult to understand and explain. To understand the responses of the brain to architecture and the built environment, its major anatomical characteristics should be explained in terms of human behavioral, sensational, emotional, and cognitive experiences and thoughts in the built environment. Gaining an understanding of the major parts and systems of the brain will allow us to research how we think, perceive, move, remember, learn, and feel about the built environment. The more we deepen our knowledge of the human brain, the closer we may be to understanding human experience in the built environment.

The entire nervous system of humans coordinates bodily actions by transmitting signals between specific parts of the body and brain and is dependent on neurons for its activity. These cells are the functional units of the brain, spinal cord, and entire peripheral nervous system(Andreassi, 2007). Neurodevelopmentally, the brain has three major parts: forebrain, midbrain, and hindbrain. The forebrain is evolutionarily the most developed part of the brain and includes the cerebral cortex and subcortical structures. The cerebral cortex consists of four main parts with specific functions: the frontal, parietal, temporal, and occipital lobes (Borden, Forseen, and Stefan, 2015). The sub-cortical structures include the limbic system, thalamus, hypothalamus, and pituitary gland. The limbic system is one of the most important systems of the brain because it is responsible for emotions, memory, learning, and cognition (Carlson, 2012). The limbic system has three main sub-systems: the hippocampus, amygdala, and basal ganglia. The hippocampus is in charge of navigation and the creation of memory of episodes (Pallasmaa et al., 2013); the amygdala is in charge of emotional reactions, whereas the basal ganglia are in charge of motor movement (Møller, 2003). Additionally, the sensory system of the human brain is crucial for understanding the sensational responses of a human being to the built environment. The sensory systems

of the brain include the visual system, auditory system (hearing), olfactory system (sense of smell), sense of taste, somatic sensation system (sense of touch), sixth sense, and proprioception (which monitors muscle contractions, movements, and positions of the body). Proprioception uses sensory organs that are similar to those of conscious senses. Proprioception obtains its main input from muscles, tendons, and joints. Such information is integrated with input from the vestibular apparatus (Møller, 2003).

2.4.3 Methods and techniques that have emerged at the intersection

Methodologically, the collaboration between neuroscience and architecture has been established within developments in neuroscience methods, such as psychophysiological measurements and brain imaging techniques. Given the articulated nature of the study area, the collaboration is based on a multidisciplinary approach that covers the environment, behavior, and neuroscience methods using digital tools. Figure 2.1 shows the methods related to neuroscience and architecture studies that have been compiled from studies available in the literature.

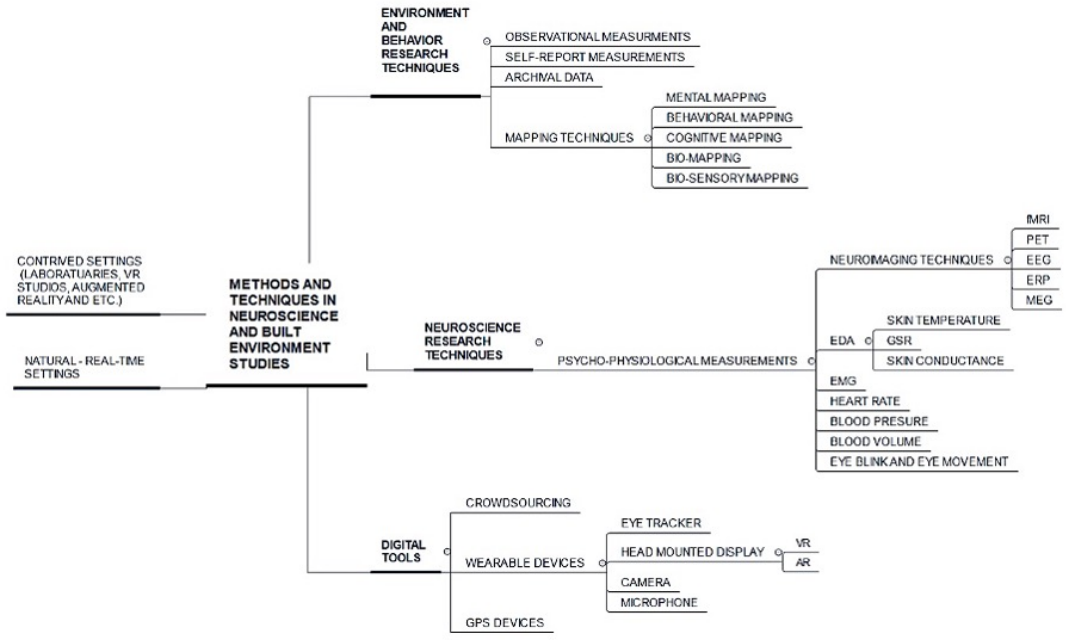


Figure 2.1 : Research techniques related to the built environment and neuroscience studies, prepared by the authors.

2.4.3.1 Environment and behavior research techniques

The prominent author Zeisel (1981), who formerly presented research tools for environment and behavior studies, revised the tools to reflect the neuroscience knowledge acquired from recent developments in neuroscience methods and technologies. Zeisel (2006) formulated environment, behavior, and neuroscience studies by specifying individual variables for each domain as physical environmental characteristics, neuroscience dimensions, physiological factors, and behavioral and performance outcomes to understand human experience further in association with the psychological phenomenon.

Mapping techniques are several of the most important tools in environment and behavior studies that have been improved by developments in neuroscience and architecture. Cognitive and mental mapping techniques, which are precursors of

current mapping techniques, encompass the cognitive processes that enable researchers to acquire, code, store, recall, and manipulate information about the nature of their spatial environment (Downs & Stea, 1973). Advances in bio-sensory technologies, which supply data for the visualization of emotional responses, have created new mapping techniques, including bio-mapping, bio-sensory, and multiple bio-sensory mapping. Bio-mapping techniques investigate the implications of creating technologies that can record, visualize, and share our intimate body states (Nold, 2009). The resulting bio-sensory devices offer new research opportunities that enable the measurement of biological data obtained in natural real-time, rather than contrived, settings (Chen et al., 2016).

2.4.3.2 Neuroscience research techniques

Neuroscience research techniques encompass a large and diverse area. Psycho-physiological measurements are currently several of the most important neuroscience research techniques. These techniques are based on the signals emitted from the central and peripheral nervous systems and are used to explain various questions about our human make-up, including mental and behavioral aspects.

Many different types of techniques are included under the broad heading of psycho-physiological measurements. Neuroimaging techniques are several of the most useful sources of information, and the data they provide underpin the relations between neuroscience and architecture. The most familiar neuroimaging techniques used to

understand brain functioning include functional magnetic resonance imaging (fMRI), positron emission tomography (PET), and magnetoencephalograms (MEGs). fMRI is used to measure changes in neuronal activity in different areas of the brain during functioning and to create detailed photograph-like representations. PET helps in examining normal and abnormal brain functions. MEG is used to measure the neuromagnetic fields of the brain. The psycho-physiological measurement techniques used in the measurements of the central nervous system can be classified as electroencephalography (EEG) and event-related brain potentials (ERPs). EEG relies on transdermal readings of electrical signals through the scalp. This technique uses at least two and sometimes up to 256 electrodes to measure the differences in electrical charge (the voltage) between pairs of points on the head. Two basic brain wave patterns can be identified using EEG measurements: alpha, which is larger, slower, and more regular, and beta, which is smaller and faster. In addition to these two brain waves,

delta and theta waves have recently been observed. Delta waves are typically low frequency and high amplitude, whereas theta waves are slow and less commonly observed (Andreassi, 2007). ERP is another technique derived from EEG recordings. This potential is differently generated as a response to specific stimuli that are time-locked to stimulus events (Andreassi, 2007).

Electromyography (EMG) is an important technique for measuring the peripheral nervous system. EMG measures the electrical activity produced by skeletal muscles. Additionally, the use of EMG allows researchers to detect very small facial movements that are not observable from looking at the face itself (Gökçay, Didem; Yıldırım, 2011). Measurements of heart rate, blood pressure, electrodermal activity, pupil response, blood volume, eye blinks, eye movements, skin conductance, and skin temperature are other important ways for investigating the autonomic and somatic nervous systems.

2.4.3.3 Digital tools

In addition to these techniques, several useful digital tools have emerged. Crowdsourcing is a digital tool that helps gather data from social and geosocial media, such as Twitter, via smartphones (e.g., using the RADAR SENSING app). Wearable devices, such as portable minicomputers, equipped with various sensors, sensor wristbands (body monitor systems), GPS, microphones, and cameras are also important digital tools. Furthermore, bio-information coupled with GPS technologies

and mobile camera systems that combine emotional responses with locations enables eliciting emotional and sensory responses in real-time settings in the built environment (Chen et al., 2016). Headmounted devices, such as virtual reality (VR) glasses, are commonly used in neuroscience and architecture studies to strengthen subjective experiences by delivering an environment similar to the real one.

2.5 Analysis and synthesis: Projecting the conceptual layout of neuroscience and architecture

To analyze and synthesize the conceptual developments in the field, theoretical studies (including books, book chapters, reviews, and theoretical articles) and experimental articles were examined in separate groups, and the developing and emerging concepts were extracted. Seventy-one studies met the inclusion criteria of the review. A total of 15 sources were books and book chapters, whereas 50 sources were articles, including 3 reviews, 27 theoretical articles, and 20 experimental articles. All articles returned by the keyword searches were analyzed and categorized on the basis of their subjects.

The data gathered from this analysis were compared by categorizing the overlapping, similar, and different concepts in each group. First, the comparison in Table 2.1 infers that the overlapping concepts, which originated mainly from environment and behavior studies, continued to be developed and applied to the experimental studies at the intersection of neuroscience and architecture. However, several important concepts in environment and behavior studies, such as privacy, territoriality, crowding, personalization, sense of place, place identity, and sense of attachment were nonexistent in either theoretical or experimental studies at the intersection. Hence, these concepts could not have been adopted in neuroscience yet. Second, even though several concepts were not literally the same in both groups of studies, they evoked similar connotations. For example, memory and scenarios in theoretical studies appeared as shifting scenarios/narratives in experimental studies. These scenarios were differentiated, but similar conceptualizations made us think that these concepts had no consensus from the perspective of neuroscience and architecture. Lastly, most of the emerging concepts explained by the theories of neuroscience and architecture, including thigmotaxis, pareidolia, proxemics, proprioception, and mnemonics, have not been investigated in the experimental studies yet.

Table 2.1 : A comparison of theoretical and experimental studies based on developing and emerging concepts at the intersection of neuroscience and architecture prepared by the authors.

	Theoretical studies	Experimental studies
overlapping	Well-being, Wayfinding, Imageability, Multisensory experience, Spatial orientation, Spatial navigation, Biophilia, Restorativeness, Health effects, Spatial cognition	Well-being, Wayfinding, Imageability, Multisensory experience, Spatial orientation, Spatial navigation, Biophilia, Restorativeness , Healing effects, Spatial cognition
similar	Rectilinearity & curvilinearity, Bilateral symmetry, Memory, scenarios, Environmental stress, Mirror neurons	Architectural space geometry, Shifting scenarios/ narratives, Perceived stress, Embodied simulation mechanisms
different	Embodiment, Hapticity, Exploration, Thigmotaxis, Pareidolia, Proxemics, Proprioception, Mnemonics, Neurological impairment, Wellness	Neural mechanisms, Psychogeography, Spatial arrangements, Appreciation of ambiances, Neuro-assessment of human experience, Positive-negative user experience, Precognitive stages of human experience, Visual engagement, Pre-attentive/ unconscious experience, Phenomenological experiences, Depth of experience, Experiential quality, Experiential intensity, Natural experience of architectural spaces, Aesthetic appreciation/judgment

The nature of neuroscience knowledge requires a deep analysis of experimental studies. The types of outcomes extracted from the experimental articles were categorized as developing and emerging concepts, human experience, built environment features, and measurement techniques. The analyses indicated five major groups based on the subjects of the articles, as shown in Table 2.2 : (1) restorative and stress-reducing effects of the environment, which deals with human physical and mental health; (2) aesthetic judgement and/or appreciation of built environment features; (3) pedestrian experience, navigation, and wayfinding; (4) visual engagement, attention, and imageability; and (5) characteristics of human experience with a specific focus on phenomenological, positive/negative user experiences, sensory experiences, and experiential intensity. The categorization of the groups was also evaluated on the basis of their relationships with human experience, built environment features, and measurement techniques. Human experiences in the examined articles included behavioral, emotional, sensational, and cognitive responses covering conscious, unconscious, and subconscious experiences. Built environment features encountered in the experimental studies were varied in scale from interiors to

urban spaces. With respect to measurement techniques, measuring the data with these techniques was difficult despite the great variation. The devices used in the psychophysiological measurements collected a large amount of raw data that made drawing meaningful inferences difficult for the researcher. Given the precision of the devices, exposure to all types of external stimuli in real-life settings prevented the collection of accurate data about human experience. Thus, most of the experimental studies were conducted in contrived settings, such as laboratories and VR studios. Although VR settings are close to real-life settings, they are not wholly adequate for thoroughly understanding human experience.

The review results show that most of the conceptualization in the field is generated by theoretical studies. The concepts presented in theoretical studies and examined in experimental studies do not match. As shown in the third group in , several concepts developed in theoretical frameworks have not yet been verified in experimentalworks. This finding implies the difficulty of formulating these concepts as testable hypotheses in experimental studies and the challenges of experimental studies in measuring data. However, the growing body of experimental studies contributes to the understanding of the nuances of the concepts presented in theoretical studies. Overall, the review results highlight that differences between theoretical and experimental studies indicate the great potential for and challenges in associating theoretical with experimental findings; a large array of concepts requires further research.

Table 2.2 : The outcomes extracted from the experimental articles prepared by the authors.

Emerging & Developing concepts	Human experience	Built environment features	Measurement techniques	References
Restorative and stress reduction effects of environments	Well-being, restorativenessand stress	Natural environment and built environment without nature, building-integrated vegetation, the stimulus in interior spaces (vegetation, music and visual features), bed positions and orientations	fMRI, EEG, VR, EDA, HRV, questionnaire, self-report, post-test measurements,	Mart´ınez-Soto et al. (2013); Hekmatmanesh et al. (2019); Higuera-Trujillo et al. (2019)
Aesthetic judgment/ appreciation	Pleasure, familiarity, novelty, comfort, pleasantness	Arrangements of furniture, windows, and doors, visual complexity, architectural decorum, typicality, ambiances of interior spaces	EEG, VR, aesthetic judgment tasks, rankings	Grima Murcia et al. (2019); Vannucci et al. (2014); Vecchiato et al. (2015)
Pedestrian experience Navigation Wayfinding	Mediation, attention, anxiety, displeasure, positive and negative emotions, intense and mild, pleasant and unpleasant,	Urban characteristics of a place (edges, patterns, shapes, narrative), urban spaces and forms (building shapes, textures, isovist parameters, visual entropy, visual fractals), the physical characteristics of routes, ceiling height	EEG, VR, GIS, GPS, body sensors, self-report, video recording,	Li et al. (2016); Erkan (2018)
Visual engagement Visual attention Imageability	Visual attention, avoidant behavior, conscious and unconscious attention, efficient, pretty, safe, pleasant, interesting	Spatial characteristics of urban streets (street edges, ground, sky, the existence of people and objects, adjacent realms), the characteristics of civic monuments (front facades), architectural space geometry (square, round, sharp, curvy)	EEG, VR Eye tracker, MoBI, video recording, questionnaire, self-report, scorecards	Simpson et al. (2019); Sussman and Ward (2019); Shemesh et al. (2017); Banaei et al. (2017); Hollander et al. (2019)
Phenomenological experiences Experiential intensity Positive/negative user experience Multisensory experience Natural experience of architectural spaces	Relaxation, excitement, engagement, stress, focus, interest, attention, appreciation, peace, beauty, connectednes, anxiety, pleasure, motivation, pleasant and frustration	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, ease of access, symmetry/asymmetry), design features of interior spaces as level of luminance, color of the surfaces, openness in space, natural daylight,	fMRI, EEG, VR, EDA, HRV, questionnaire, self-report, post-test measurements, crowdsourcing, semantic differential scale	Vijayan and Embi (2019); Bermudez et al. (2017); Ergan et al. (2018); Higuera-Trujillo et al. (2019)

2.6 Conclusion

The present review explored the influence of the built environment on human experience by using approaches from neuroscience by systematically examining the

existing literature within the continuum of precedent, ongoing, and emerging theories and methodologies. The review theoretically and methodologically contributed to the crossdisciplinary field of neuroscience and architecture and provided the general conceptual framework needed for finding a common ground on which to conduct interdisciplinary studies.

All theoretical and methodological developments that meet at the intersection of architecture and neuroscience have created the necessity of opening up a discussion about collaboration in these disciplines. Advances in science and technology have given rise to such new scientific research methods and measuring techniques as psychophysiological measurements and neuroimaging techniques. All of them are now being used to explore human experience in the built environment in a multidimensional, holistic, and comprehensive way. From this perspective, developing and emerging concepts were discussed to understand the influence of the built environment on humans' behavioral, sensational, emotional, and cognitive responses with a high degree of objectivity.

The systematic qualitative review of the literature at the intersection of neuroscience and architecture shows that the variety of theories and concepts that explain the field is wide. Indeed, most of the concepts have been developed in theoretical terms, but experimental studies have not yet succeeded in verifying most of these theories. The findings of the experimental studies remain isolated as urther experiments face challenges in measuring and associating the data. Thus far, they have touched a small part of the theoretical output, indicating that a large array of concepts requires further research.

Considering the great potential inherent in combining scientific knowledge with human-specific faculties, such as behavior, thought, sensation, and feeling, the relationship between human experience and the built environment determined using approaches from neuroscience will notably influence future studies. The intersection of neuroscience and architecture is likely to be beneficial for (1) evaluating the performance of an existing built environment, (2) providing evidence-based design decisions, and (3) improving the quality of life of humans and the society.

Neuroscientific knowledge can provide evidence-based and objective data whose absence to date has been one of the greatest shortcomings of current theories in their

attempts to examine human experience in the built environment. Thus, developments in neuroscientific knowledge will not only allow us to grasp the needs, responses, and experiences of human beings efficiently in built environments but also continue to play an increasingly important role by providing direction to the future domain of architecture and built environment studies.

Overview

The interactions between architecture and neuroscience based on human experience were studied from muliple perspectives, including theoretical and methodological approaches, and discussed how each disipline crosses its boundary to create a holistic approach. First, the key theories and methodologies leading to the neuroscience approach in architecture were elicited from the literature. Second, the conceptual framework of the neuroscience approach in architecture concerning the human experience was developed through the examination of theoretical and experimental studies. Finally, the potentials, challenges, and gaps in the field regarding the associations between the theoretical studies and their implications in experimental studies were revealed. The outcomes of the paper guide the research designs of second and third paper.

3. MINDING THE CITY: A CASE STUDY ON THE NEW CONCEPTUALIZATIONS OF HUMAN EXPERIENCE IN THE BUILT ENVIRONMENT[2]

3.1 Introduction

Research on the human experience in the built environment has extensive literature encompassing various disciplines. In the past several decades, human experience has played an essential role in architecture and urban studies with a particular interest in scientific perspectives and findings. The new perspectives based on neuroscience and cognitive sciences have become the most effective multi-disciplinary approach to studying human experience (Eberhard, 2007; Pallasmaa et al., 2013; Zeisel, 2006). Cognitive architecture (Hauptmann et al., 2010; Sussman & Hollander, 2015) and neuro-architecture (Edelstein, 2015; Frascari, 2012) have emerged as new study fields under these circumstances prioritizing the human response to environmental stimuli with a specified interest in the human brain, mind, and psyche. Therefore, it would be of particular interest to investigate human experience in the built environment through the lens of those emerging fields concerning it as an individual human self, interpersonal human beings, and through human-built environment interactions and human-nature interactions.

The present study intends to mind the city by taking the information gathered through the senses and processed in the human brain as the primary concern in understanding the human experience in the built environment. Minding the city considers Lynch's (1960) theory of reading the city as a pioneering study model. The empirical inquiry of individual human experience first appeared in Lynch's studies, mainly concerning the form of the city, and eventually ended up with an inspiring method and mind-

[2] This chapter is based on the following publication: Karakas, T., Dumlu, B.N., Yildiz, D. (2023). "Minding the city: A case study on the new conceptualizations of human experience in the built environment." *A|Z ITU JOURNAL OF THE FACULTY OF ARCHITECTURE*, *20*(1),163–179. https://doi.org/10.5505/itujfa.2022.53179

opening theory of urbanism. Lynch (1960) prioritized the visual perception and the look of the cities in capturing the urban patterns and categorizing them with their features. However, minding the city concentrates on understanding the experiential use of an urban setting through the knowledge of the human brain. The insights of brain studies contribute to understanding the sensory, cognitive, emotional, and behavioral dimensions of human experience in architecture and the built environment. Additionally, they have provided valuable information for creating common grounds between the disciplines to conduct a systematic inquiry for understanding the human experience (Karakaş & Yıldız, 2020). This refreshing approach constitutes a relatively new area dealing that requires a well-defined conceptual framework. Therefore, as the study's primary objective, minding the city investigates the conceptualizations based on human evolutionary cognitive tendencies: biophilia, bilateral symmetry, mirror neurons, pareidolia, proxemics, thigmotaxis, curvilinearity and rectilinearity.

As humans, we come from a common evolutionary past shaping our tendencies and priorities that are primarily unconscious, innate, and hidden. The conceptualizations based on human evolutionary tendencies have been adapted from broad disciplinary studies covering biology, psychology, anthropology, cognitive sciences, behavioral sciences, neuroscience, and cognitive sciences. However, the literature relating the conceptualizations to architecture and the built environment is a maturing area with flourishing studies on cognitive architecture and neuro-architecture. Sussman and Hollander (2015) introduced the new conceptualizations in the built environment as a set of principles, including biophilia, bilateral symmetry, pareidolia, proxemics, thigmotaxis, and curvilinearity and rectilinearity. Morabito (2016) extended the set by adding mirror neurons and mnemonics. Hollander and Foster (2016) studied the concepts, named them cognitive architecture (CA) principles, to score an urban setting by using EEG (electroencephalography) measurements without reference to the subjective experience of participants. However, there is no adequate research that has investigated these conceptualizations through an empirical inquiry in terms of adding the insights of individuals on understanding the human experience in an urban setting. Therefore, we formulated the research question: "How would the human experience be understood through the new conceptualizations based on human evolutionary cognitive tendencies in a real urban setting?".

The present paper was designed as qualitative research employing a case study strategy to develop explanatory and exploratory empirical inquiry. Therefore, we used observational measurements, mapping techniques, and the declaration of participants' own experiences. A challenging problem arising in this domain is operationalizing the available knowledge for minding the city study because of the novelty of the study field. Thus, we developed two phases of the case study. First, we designed a preliminary stage which was the pilot study. Then, we conducted the main study. Both studies included fieldwork designed as workshops. After a brief on the pilot study identifying its contributions, the main study was presented in detail. The fieldwork of the main study developed for the Eastern Mediterranean University 9th International Design Week with the name "Minding the City / Famagusta: Bring your brain into the built environment." Throughout the workshop, comprehensive visual and verbal data was collected. The data were represented as multilayered and cognitive outputs, including videos, photographs, diagrams, sketches, architectural drawings, and notes.

Finally, the collected data were analyzed and synthesized to produce visual and verbal representations of the conceptualizations and to generate the urban codes [1]. The final outputs of the study were cognitive maps, digital drawings, and generated urban codes developed separately for each conceptualization. They were presented and discussed within the related literature in the discussion part. In conclusion, an overall interpretation of the case study was developed.

3.2 The New Conceptualizations

3.2.1 Biophilia

In 1984, Edward O. Wilson defined the term biophilia as "the innate tendency to focus on life and lifelike processes" (Wilson, 1984, p.1). Followingly, the concept of biophilia, even if it was not mentioned as biophilia specifically, has been studied in diverse study fields, including philosophy, anthropology, psychology, physiology, medicine, environmental studies, architecture, and urban studies. Briefly, biophilia is an urge, a biological need, and an evolutionary tendency to be connected to nature and other organisms. In the literature, the concept of biophilia has been discussed through the savannah hypothesis (Orians, 1980, 1986), biophilia hypothesis (Stephen R. & Edward O., 1993), connectedness to nature (Zylstra et al., 2014), attention restoration theory (Kaplan, 1995), and stress recovery theory (Ulrich, 1984; Ulrich et al., 1991)

which are concerned about human mental and physical health and well-being. Furthermore, in recent years, the application of biophilic patterns to design processes has gained importance regarding psychological benefits and effects on health and well-being (Ryan et al., 2014). Therefore, we applied the biophilia concept to our study to investigate the human experience as an individual human self and through human-nature interaction.

3.2.2 Bilateral symmetry

Bilateral symmetry is a biological term used to explain symmetry with respect to left and right or a vertical axis that divides an organism into two identical parts (Coburn et al., 2017; Moubayidin & Østergaard, 2015). As an essential gestalt principle (Koffka, 1935), symmetry is not only one of the most crucial design patterns (Alexander, 2002) and design organization schemes but also one of the most commonly used design principles that have roots in architectural history (Ching, 2007). Furthermore, according to neuroscience studies, our brain and visual system are susceptible and responsive to symmetry (Ramachandran & Hirstein, 1999), and symmetry in things significantly affects our aesthetic judgment of beauty (Jacobsen et al., 2006). Therefore, we searched for bilateral symmetry in the built environment to study the human experience through human-built environment interaction.

3.2.3 Mirror neurons

The concept of mirror neurons was adapted from neuroscience studies. The mirror neurons, initially discovered in macaque monkeys' brains, are a specific group of neurons that fires both during the execution of an action and observation of the same action while performed by others (Gallese et al., 1996; Rizzolatti et al., 1996). Followingly, mirror mechanisms were discovered in the human brain (Rizzolatti & Craighero, 2004; Rizzolatti & Sinigaglia, 2008), which is a more complex issue including not only the actions of individuals but also sensations, feelings, emotions, and mental processes of individuals. According to neuroscience studies, the functional role of mirror neurons in humans might be action imitation and action understanding (Rizzolatti & Craighero, 2004). Therefore, those functionalities may contribute to understanding and repeating the behavioral responses of individuals to certain stimuli. Furthermore, they may create an understanding of a shared experience based on individuals' actions, feelings, emotions, and intentions. We applied the knowledge

derived from neuroscience studies of mirror mechanisms to the built environment to create an understanding of the human experience based on interpersonal relations.

3.2.4 Pareidolia

Pareidolia is one of the oldest biological traits of human beings. According to the Oxford Reference (Concise Medical Dictionary, 2010, pareidolia entry), pareidolia is the "misperception of random stimuli as real things or people," a broader term including all human and non-human characteristics. For example, the tendency to seek and recognize facial expressions in things means facial pareidolia, which is the most common type of pareidolia.

Faces are so crucial for the human perception that evolutionarily, we prioritize faces and people (Sussman & Hollander, 2015), and face perception is our most highly developed skill (Haxby et al., 2000). Furthermore, as Gallese (2022) stated, 'the face is the first means used to build interpersonal relations.' So, naturally, we tend to see faces in buildings and objects. However, in the literature, few studies relate the pareidolia concept with the design disciplines and aesthetics, which establishes its relevance for design contexts (Wodehouse et al., 2018) and its effects on human affective perception (Abbas & Chalup, 2021; Chalup et al., 2010). Therefore, we applied pareidolia concepts to our study to investigate the impact of face-like forms on the human experience through human-built environment interaction.

3.2.5 Proxemics

Proxemics is a spatial behavior based on the regulation of distancing between both people and tactile stimuli regarding body-space relations. The term proxemics was first introduced by Hall (1959, 1969), which refers to studying spatial relations. Hall (1969) identified four measurable personal spheres referring to a distance between two people; 1) intimate distance, less than 45 cm, 2) personal distance, ranging from 45 cm to 120 cm, 3) social distance, from 120 cm to 360 cm, and 4) public distance, from 360 cm to 760 cm. Thus, those distances become a helpful tool for understanding the human experience in the built environment. As Dumlu (2020) explained, humans regulate their proxemic distances within the environments they are immersed in and locate themselves with personal, social, or public distance according to how they intend to perceive a building element. Therefore, we studied the concept of proxemics to understand the human experience as interpersonal human beings, human built-

environment interaction, and human-nature interaction regarding the regulation of inter-relational distancing.

3.2.6 Thigmotaxis

Thigmotaxis is a spatial strategy used by humans and animals, which "is a way an organism organizes behavior relative to tactile stimuli" (Kallai et al., 2007). In the literature, various terms are used instead of thigmotaxis as wall-hugging, wall-touching, wall-following, centrophobic behavior, and agoraphobia (Creed & Miller, 1990; Harris et al., 2009; Kallai et al., 2007; Schnörr et al., 2012; Sussman & Hollander, 2015; Walz et al., 2016). Briefly, thigmotaxis is the tendency to stay close to the boundaries of space during spatial exploration, which is directly related to the human experience of architectural and urban space. In architecture and urban studies, Jan Gehl, one of the most critical actors in examining citizens' public life and behavioral experiences, introduced the concept of the edge effect in 1987 (Gehl, 1987). According to Gehl (2011), people move close to the boundaries of public spaces and choose physical boundaries or threshold locations where they can see the whole area clearly while standing and sitting, a tendency similar to thigmotaxis. We investigated the thigmotaxis concept to understand the human experience through human-built environment interaction and human-nature interaction concerning the boundaries of space.

3.2.7 Curvilinearity and rectilinearity

The influence of curvilinearity and rectilinearity have been studied from the perspectives of various disciplines over the years, such as architecture, neuroscience, psychology, aesthetics, and neuro-aesthetics. Curvilinear and rectilinear forms as physical attributes might influence the human experience regarding behavioral, emotional, and cognitive responses and the aesthetic experience of the users. In the literature, it has been investigated through diverse topics such as the potential of triggering emotional responses (Dazkir, 2009; Madani-Nejad, 2007), approach and avoidance behavior (Vartanian et al., 2013), environmental preferences (Bar & Neta, 2006; Leder et al., 2011) and beauty judgment (Coburn et al., 2017; Vartanian et al., 2013, 2019). Most studies indicated that curve lines and forms are preferred, more beautiful, pleasing, visually complex, approachable, serene, and joyful than rectilinear shapes and forms made of straight lines. Therefore, we studied the concept of

curvilinearity and rectilinearity to understand the human experience through the human-built environment interaction with the contours of a space.

3.3 Method: Developing a Case Study

We conducted a case study research design to create an explanatory and exploratory empirical inquiry. The study's explanatory target is to interpret the behavioral patterns that occurred in the experiential use of an urban setting by exploring conceptualizations based on human evolutionary cognitive tendencies. The exploratory target of the study is to investigate those conceptualizations in understanding the human experience as an individual human self, interpersonal human beings, human-built environment interaction, and human-nature interaction to apply to a theory-building structure. Therefore, the case study investigated the conceptualizations in real-life contexts by applying systematic observation, self-declaration tools, and mapping techniques to reach multiple sources of evidence. The case study was developed through sequential workshops in Istanbul and Famagusta, presented as the pilot and the main study.

3.3.1 Participants

We recruited workshop participants with an open call for senior architecture students. The participants of the pilot and main study have a joint team. We designed the pilot study as a workshop for architecture students studying at the Fatih Sultan Mehmet Vakıf University on 4-6 April 2019. The application requirements included 1) taking a photo from an urban environment representing a particular organizational scheme parallel to the ground surface and 2) writing a short essay explaining the selected vantage point. We aimed to recruit fully immersed students. Five students, three of them were 4th year, and two were master's students, were chosen. We trained the students in the course of the pilot study.

For the main study, we attended the 9th International Design Week held at Eastern Mediterranean University in Cyprus on 8-10 May 2019 with the trained students. Additionally, we recruited five new participants who applied through design week to join the study team. The newcomers were trained through the presentations and the pilot study findings. We coupled the trained students with the new participants to increase the awareness and attention levels of the study groups. It was crucial for the

study's success that the participants would be prepared for what to observe and how to make their observations and experiences explicit. Then, we assigned the concepts to each group to make them employ the arrangements in the field.

3.3.2 The case study research design

We designed the pilot study as a preliminary study for the main study, including the field studies and necessary preparations for future studies. The content of the whole case study research design is shown in Figure 3.1.

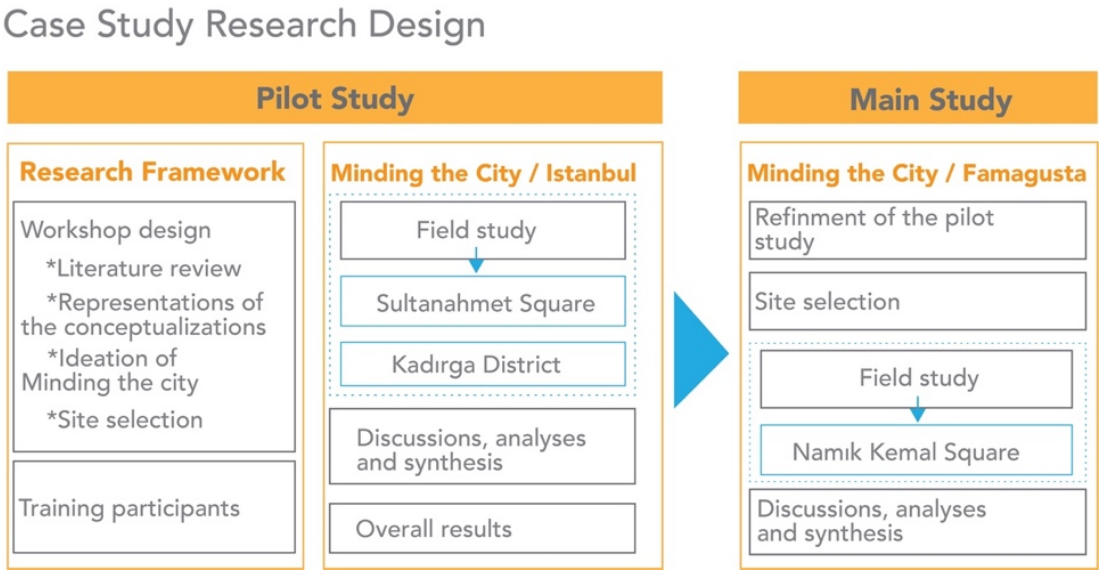


Figure 3.1 : The case study research design.

Within the pilot study, we developed a detailed study covering the requirements of the research framework and the field studies; 1) workshop design and the preparation of the workshop materials, including literature review, representations of the conceptualizations developed by the research team, ideation of minding the city, and site selection 2) training the participants. The fieldwork of the pilot study was conducted with the Minding the City / Istanbul: Bring your brain into the built environment workshop, while 'Minding the City/Famagusta: Bring your brain into the built environment workshop was led for the main study.

The workshop design has a generic three-day flow applied to both studies. The research pattern of the workshop included individual and collective processes considering both in-studio and on-site examinations. As the workshop leaders, we were next to the participants to clarify the obscurities in all the phases. However,

during the data collection on the site, we had the recognized outsider position aiming not to create research bias and to observe the participants' study experiences.

On the first day of flow, the workshop starts with the presentations that include three topics; 1) What does Minding the City Mean?, 2) How to observe?, and 3) Conceptualizing the built environment. First, we introduce the idea of minding the city, which refers to an alternative way of reading the city. Then, we trained the students on the systematic observation and mapping techniques, the defined conceptualizations, and the production techniques of the final output. After the training sessions, we introduce the study fields' context to the participants. Followingly, the on-site process starts with the individual observations of the participants as secret outsiders and full participant positions. Next, the participants observe the user's environmental behaviors and the physical traces on the site left behind. They used mapping, counting, tracing, photographing, and sketching tools to collect the data. They searched for biophilia, bilateral symmetry, mirror neurons, pareidolia, proxemics, thigmotaxis, curvilinearity and rectilinearity, and mnemonics concepts. However, the concept of mnemonics was excluded in the course of the pilot study. The concept of mnemonics could not be studied in the flow of a three-day workshop conducted in such dense urban settings due to the mnemonics' strong references to space's historical and narrative characteristics. Participants recorded their observations and experiences as annotated diagrams, photographs, drawings, sketches, and notes for each concept.

The second day is planned as an in-studio examination. First, the participants individually analyze their on-site observations and experiences to refine and classify the collected data. Then, the participants create digital drawings of their analyses, including the data reproduction and their insights. Next, we asked them to express their experiences as written statements identifying the conceptualizations. Finally, in the second half of the second day, joint discussion sessions are made to sync up all work done so far with the contributions of all participants.

The last day is planned as a collective work. Firstly, we revised the digital drawings produced by the participants to produce the final version of visual and verbal representations of the synthesized data. Then, we held a roundtable discussion to finalize the written statements as the urban codes. First, the statements written by each participant were examined and compared one by one. Then, the non-repetitive and

singular experiences were eliminated. Ultimately, the written statements based on the shared experiences were generated as urban codes framing the human experience in the built environment through human evolutionary cognitive tendencies.

3.3.3 The pilot study

Conducting a pilot study was required for many reasons. Firstly, studying a novel topic in the design disciplines demands more attention; for this reason, examining it in an existing environment reveals the knowledge for implementing it in practice. Secondly, developing a pilot study allows adding the participants' perspectives on the existing literature, enriching the study field for future studies. Thirdly, we practiced our research design's efficiency to maximize the main study's accuracy. Finally, it created the opportunity to work with experienced participants.

In the scope of the pilot study, we organized two field studies in Istanbul with different qualifications; 1) A linear route ending with a small-scale urban park, Kadırga District (Pier Loti Street and Kadırga Square), 2) A large-scale touristic square, Sultanahmet Square. The aim of selecting two sites is to compare the pros and cons for efficiently examining the conceptualizations. In addition, the participants marked the locations where they had experienced and observed the conceptualizations on the sites to gather location-based data. According to the results of the two study fields, we would be able to plan well-organized fieldwork for the main study.

We applied the three-day workshop flow to the Minding the City / Istanbul: Bring your brain into the built environment workshop. First, we introduced the study fields to the participants. The upper image of Figure 3.2 shows the locations of the sites. Kadırga District is a residential area with a port used for galleys and has a strong neighborhood culture. Sultanahmet Square is a tourist area including significantly important historical landmarks such as Blue Mosque and Hagia Sophia and a large hippodrome area. Sultanahmet Square is also named "Hippodrome of Constantinople" referring to its usage during the Byzantine.



Figure 3.2 : The maps showing the pilot and the main study fields.

The fieldwork was continued according to the workshop flow. The participants attended all individual and collective processes, both in-studio and on-site. As a final output of the study, the participants produced visual and verbal representations of the conceptualizations and the generated urban codes for two study fields. The final session, which was the overall discussion, contributed to the main study;

- Creating focused groups for each concept would be more beneficial to increase the quality of the outputs.
- Linear routes have many distractions, such as cars and bicycles, which change and affect the human experience.
- The users of a residential district are so familiar with the site that it causes an unheeding relationship with the built environment.
- Touristic squares supply more data because of the number of users and the liveliness of the space. Additionally, the users of touristic squares generally stay in place to experience the whole space and create precise interactions with

the site that make touristic urban squares more efficient for examining conceptualizations.

- Touristic squares are surrounded by designed architectural and urban features that contribute to understanding the human experience concerning the artificial features of the built environment.
- The scale of the square affects the quality of the final output. Sultanahmet Square has so many attributes that make it unable to handle the data causing a shift in the focus of the study.

3.3.4 The main study

The main study was designed based on the feedback obtained from the pilot study. Within the knowledge gathered from the pilot study, we decided to study an urban square in Famagusta for the main study, which is touristic but smaller than Sultanahmet Square; Namık Kemal Square matched our criteria.

The refinements of the pilot study include the elaboration of the research framework. The novelty of the concepts to the participants and the architecture discipline created some challenges. The participants recognized biophilia and pareidolia concepts because they were easy to picture in their minds. Bilateral symmetry, curvilinearity and rectilinearity were well understood because of their familiarity with design disciplines; however, mirror neurons and thigmotaxis required extended literature research concerning the relational studies with architecture. Unexpectedly, finding the proxemics concept in the built environment and classifying the collected data caused some conflicts as it was hard to measure precise distances between moving individuals and groups. Therefore, we developed standards for the interpretations of the data regarding the visualization through draft drawings. In the training session, we informed the participants about defined arrangements, including the type of experience, what the question should be in mind, and the sub-components based on the characteristics of the experience.Table 3.1 shows the detailed arrangements for each conceptualization. Eventually, we conducted the fieldwork as defined in the workshop flow.

Table 3.1 : The detailed arrangements for the conceptualizations.

Conceptualizations	Human Experience	The Question (Wha to look for?)	Sub-Components
Biophilia	Human-nature interaction Indıvidual human self	How do people behave around natural elements?	Sun Effect Greenery Effect Water Effect Animal Effect
Bilateral symmetry	Human-built environment interaction	How do people perceive symmetrical designs, patterns and organization schemes?	Symmetry axis Spatial symmetry Object-based symmetry
Mirror neurons	Interpersonal human being	How do people behave around other people?	Individual behavior Group behavior
Pareidolia	Human-built environment interaction	How do people perceive the face-like forms?	Architectural elements-based face perception Object-based face perception
Proxemics	Interpersonal human being Human-built environment interaction Human-nature interaction	How do people regulate inter-relational distancing?	Intimate distance Personal distance Social distance Public distance
Thigmotaxis	Human-built environment interaction Human-nature interaction	How do people move/behave around the boundaries of spce?	Floor covering effect Border effect Edge effect-vertical Edge effect-horizontal
Curvilinearity and rectalinearity	Human-built environment interaction	How do people interact with the contours of space?	Curved edge effect Sharpen edge effect

3.3.5 The location and context

Namık Kemal Square is located in the old town area of Famagusta, shown in the bottom image of Figure 3.2. There are historical places such as Lala Mustafa Pasha Mosque around the square. Lala Mustafa Pasha Mosque is a significant historical landmark mainly built as a catholic cathedral; then converted into a mosque in Ottoman times. This gothic-style building frames the square. The modern-style small

buildings are also located around the square. One of the entrances of the square has an arched stone gate.

Namık Kemal square is located in the center of the old town. The roads leading to the square are mainly occupied by commercial and public buildings that make the square significantly crucial for tourists and locals. Additionally, the roads are pedestrianized to leave spaces for public events that create more livable environments. Thus, the square's potential users and characteristics are appropriate for conducting fieldwork concerning the human experience.

3.3.6 Fieldwork and the final outputs

For the fieldwork, we applied the three-day workshop flow. First, the grouped participants visited Namık Kemal Square for fieldwork. They observed the human behaviors and the physical traces around the square. Additionally, they followed their own experiences to understand how they reacted to the built environment according to the defined arrangements.

They documented their insights about other people and their environmental features, behaviors, reactions, and current situations. Their routes were crossed from time to time, and they were also aware of their reactions to each other. The site observations took five hours. During that time, they mainly conducted individual and sub-group work. Recognizing the users' behavioral responses as defined in human evolutionary cognitive tendencies amazed the students. Additionally, they realized that they were experiencing the site the same way, consciously or unconsciously. They enjoyed going deep into their daily experiences and observing others' experiences through the eyes of their evolutionary past. Finally, each group cataloged the collected data with the name of the assigned concept and documented their data as written statements. On the second and third days, in-studio sessions were held to develop an analysis of and synthesize the collected data. Additionally, we met separately with each group to discuss the participants' insights on the assigned conceptualizations. Consequently, they transformed their observations and experiences into meaningful statements to generate urban codes of Namık Kemal Square.

The final output of the study included the production of the visual and verbal representations of the conceptualization and the urban codes for Namık Kemal Square. First, the participants developed both a general site map and individual maps for each

concept to mark their observations and experiences in a location-based manner. Then, the groups reproduced the collected data as digital drawings representing the situation that occurred at each location. Finally, they generated the urban codes as written statements for each situation. The final product was prepared as posters representing cognitive maps, digital drawings, urban codes, and a video film showing fragments from the workshop. The final outputs were presented at the closing ceremony of the EMU 9th International Design Week (Karakaş & Dumlu, 2019).

3.4 Results and discussion

In this section, the results of the case study were illustrated for each conceptualization through the final outputs of the main study. However, the concept of bilateral symmetry was better studied at Sultanahmet Square than in other fields due to the size of the square. In addition, Sultanahmet Square provided enlarged vistas and longer symmetry axes to follow reaching a place, accompanied mainly by well-designed landscape features that enhance the symmetry perception. Therefore, the pilot study's findings concerning bilateral symmetry were added to the discussion. Finally, the key findings were summarized, and the results were interpreted within the related literature.

3.4.1 Biophilia

The findings of the biophilia concepts showed that it has an appreciable impact on the human experience as human-nature interactions and an individual human self. The research on human-nature interaction has a long tradition in many areas of science. For example, Joye (2007) stated that although there are various perspectives based on the areas of psychoevolutionary, geography, or paleoanthropology in the study of human-nature interactions, these perspectives suggest a common theory on evolutionary processes of human cognitive tendencies toward nature. The theory briefly is that humans have positive affiliations with a specific set of natural elements. Additionally, Ulrich (1991) explained the positive effect of natural elements on stress reduction as restoration. He identified the green areas, sunshine, and water elements as preferable for the personal spatial experience. Figure 3.3 shows the findings of the present study.

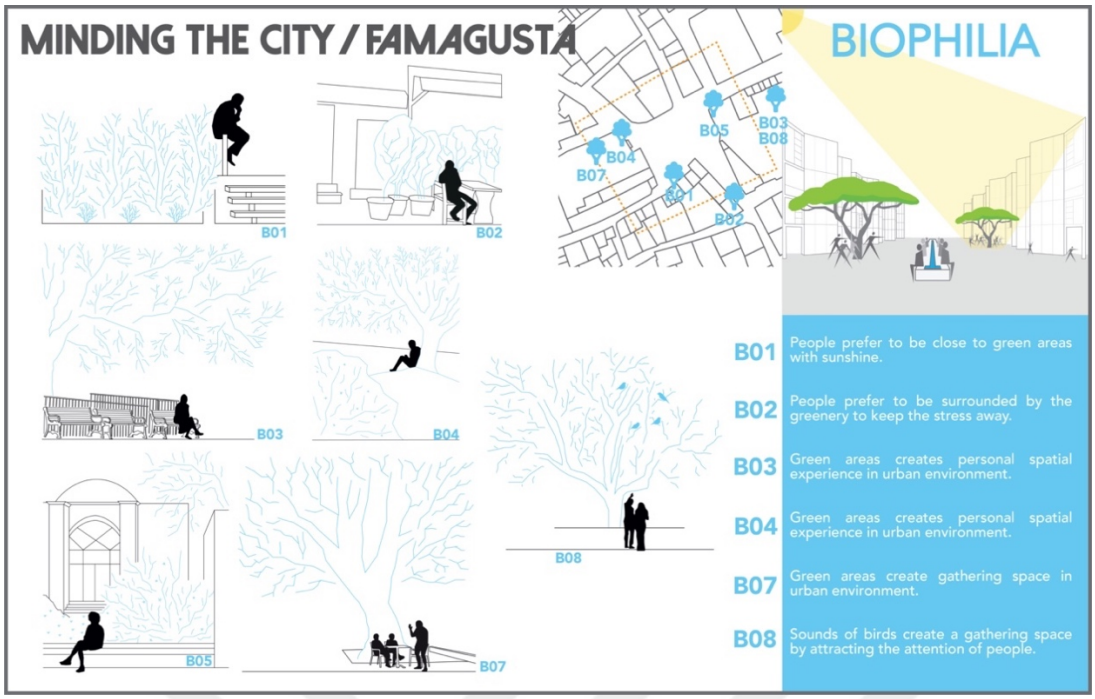


Figure 3.3 : The biophilia concept.

In line with previous studies, it is revealed that humans prefer to be close to natural elements such as greenery, sunlight, water, and animals for sitting, resting, and gathering individually and in groups. Additionally, the multisensorial dimensions of human experience are highlighted based on the sounds of birds, the smell of flowers, and the tactility of plant tissues. Going beyond the previous studies, we obtained the capability of the biophilic features from the findings to create a personal spatial experience in the urban environment. This experience offered individuals the opportunity to turn inward for self-reflection and thus provided an individual experience of the human self.

3.4.2 Bilateral symmetry

Bilateral symmetry was mainly studied through the artificial features of the study fields to examine symmetry perception based on symmetrical designs, patterns, and organization schemes. Spatial and object-based symmetry were detected at different scales ranging from a portal to a massive historic building. Figure 3.4 shows the bilateral symmetry found in Famagusta and Istanbul.

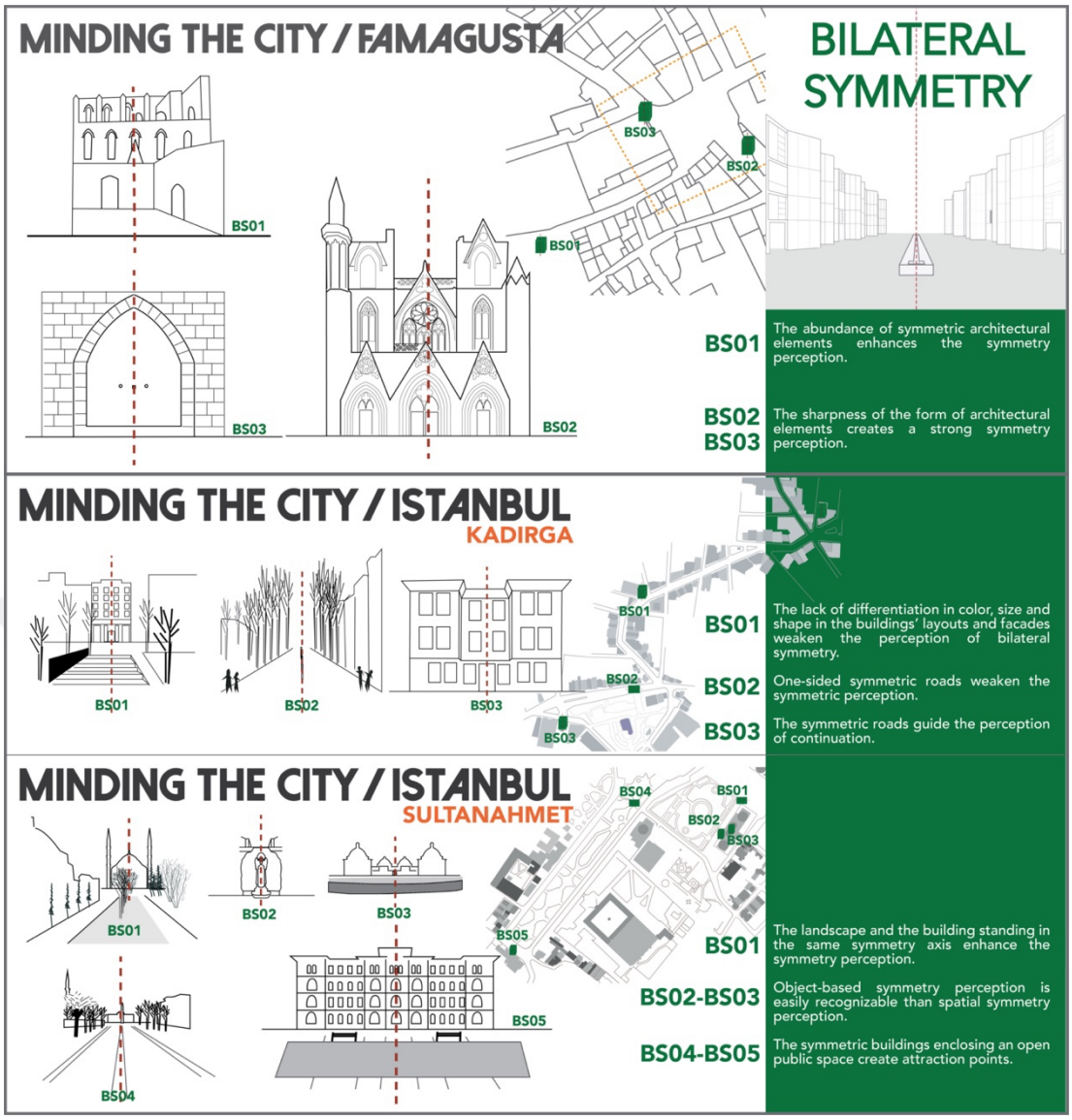


Figure 3.4 : The bilateral symmetry concept.

In the study of bilateral symmetry, the urban squares provided an excellent context where the key findings emerged. In the literature, the importance of being distant to perceived symmetry was stated by Salingaros (2020) that symmetry perception increases when experiencing from a distance, even if the strength of the perceived image decreases. Additionally, Salingaros (2006;2010;2020) and Salingaros and Sussman (2020) mentioned the importance of using a coherent pattern, contrast, complexity, engagement, emphasized vertical axis, and multiple sub-symmetries based on the knowledge of our evolutionary past, biological origins and the neural circuits of our brains. In line with those studies, one of our findings supports and furthers that perceiving a building from a distance surrounded by a symmetrically ordered urban landscape using the same symmetry axis enhances symmetry

perception. Another promising finding of our study showed that the lack of differentiation in color, size, and shape in the buildings' layouts and facades weakens the perception of bilateral symmetry by creating an endless repetition.

On the other hand, even in the absence of complete symmetry, the repetition of horizontal and vertical sub-symmetries creates a kind of symmetry perception. Additionally, it was revealed that the sharpness of architectural elements might enhance the symmetry perception. Lastly, it was found that the symmetrical building enclosing a public space becomes an attraction point.

3.4.3 Mirror neurons

Even though mirror neurons are a controversial topic in neuroscience studies regarding how the mechanisms develop in the brain, it is evident that mirror mechanisms can be observed through behaviors. Therefore, the present paper focused on evaluating the observational traces of action imitation and action understanding in the built environment (Rizzolatti & Craighero, 2004). Concerning the mirror neurons concept, human experience was searched through the acts of interpersonal human beings. The individual and group experiences were documented as relative and shared, as shown in Figure 3.5.

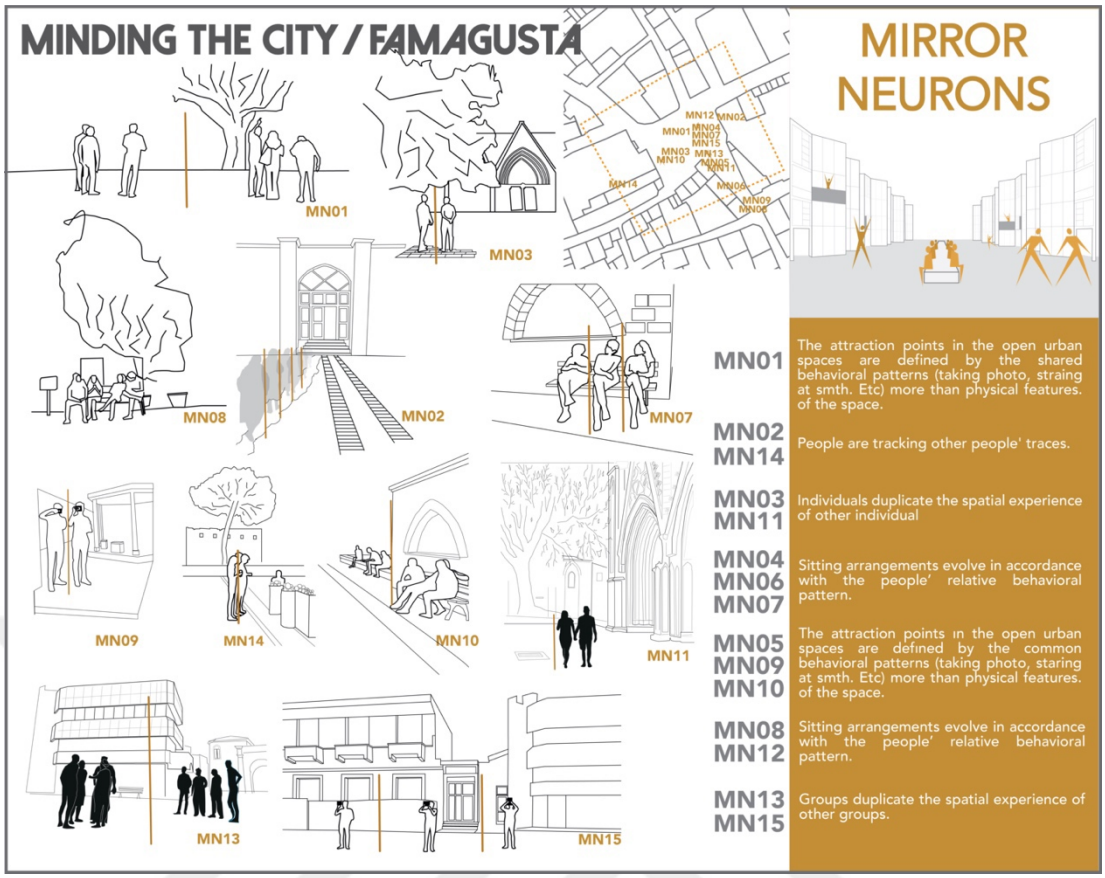


Figure 3.5 : The mirror neurons concept.

The findings revealed that humans tend to duplicate the behavior displayed by other humans in the built environment even if they do not know the logic behind the behavior. They imitate actions like taking photographs, stopping and staring at something, or standing at a spot by following the other's actions individually or in groups. Especially if there is an architectural landmark on the site, shared behavioral patterns occur around them instinctively. Additionally, people orient their actions by understanding others' actions and intentions, like following the physical traces left behind and tracking other peoples' traces.

3.4.4 Pareidolia

The pareidolia concept was investigated through human-built environment interactions seeking to find the pareidolia effect in architectural elements and urban artifacts. We followed the hypothesis of Chalup, Hong, and Ostwald (2010), explaining the perceptibility capacity of abstract face-like forms in architectural elements and their potential to evoke emotions from observers. It was inferred from

the study that face-like architectural elements are highly recognizable, including shape and emotion recognition. The findings are presented in Figure 3.6.

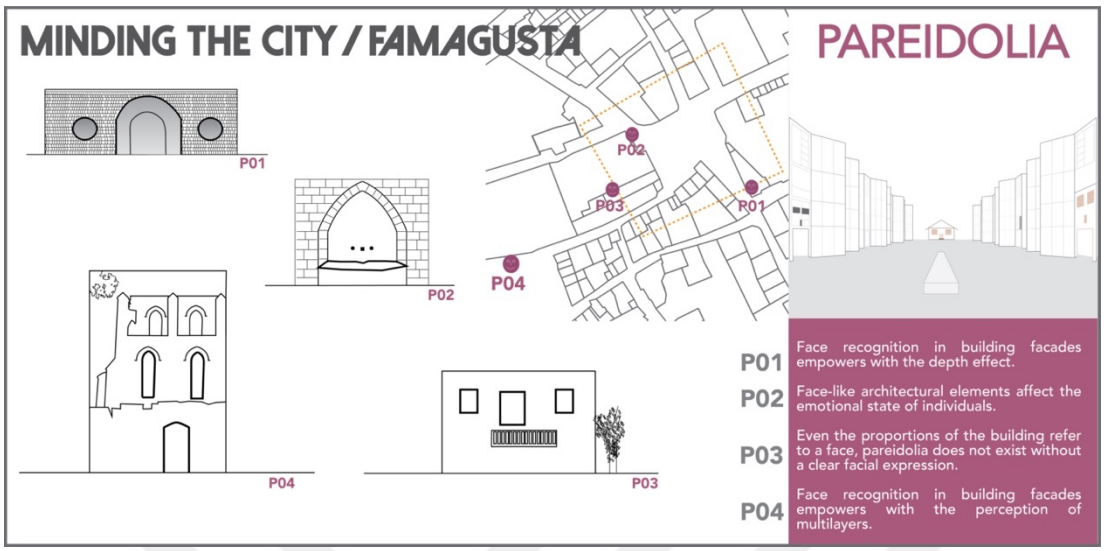


Figure 3.6 : The pareidolia concept.

One significant result of the study is that the participants look for not only facial features but also facial expressions, which impact their emotional experiences. Furthermore, the illusion of seeing face-like features around the built environment becomes a game-like experience, so looking for pareidolic features in urban space creates a positive environmental experience that triggers certain emotions in people. Additionally, the identification of pareidolic elements only appears in the case of perceiving a clear facial expression, even the proportions of the building proper. Finally, it was revealed that the multilayered elements of building facades enhance the pareidolia effect.

3.4.5 Proxemics

Carmichael & Lockhart (2012) and Hall (1963) defined proxemics through the investigation of the action of increasing or decreasing, basically regulating, the interpersonal distance and the distance between humans and their surroundings. We studied proxemic behavior by accepting their definitions and following Hall's distance categorization: intimate, personal, social, and public. Figure 3.7 indicates the variety of distancing options found on the site.

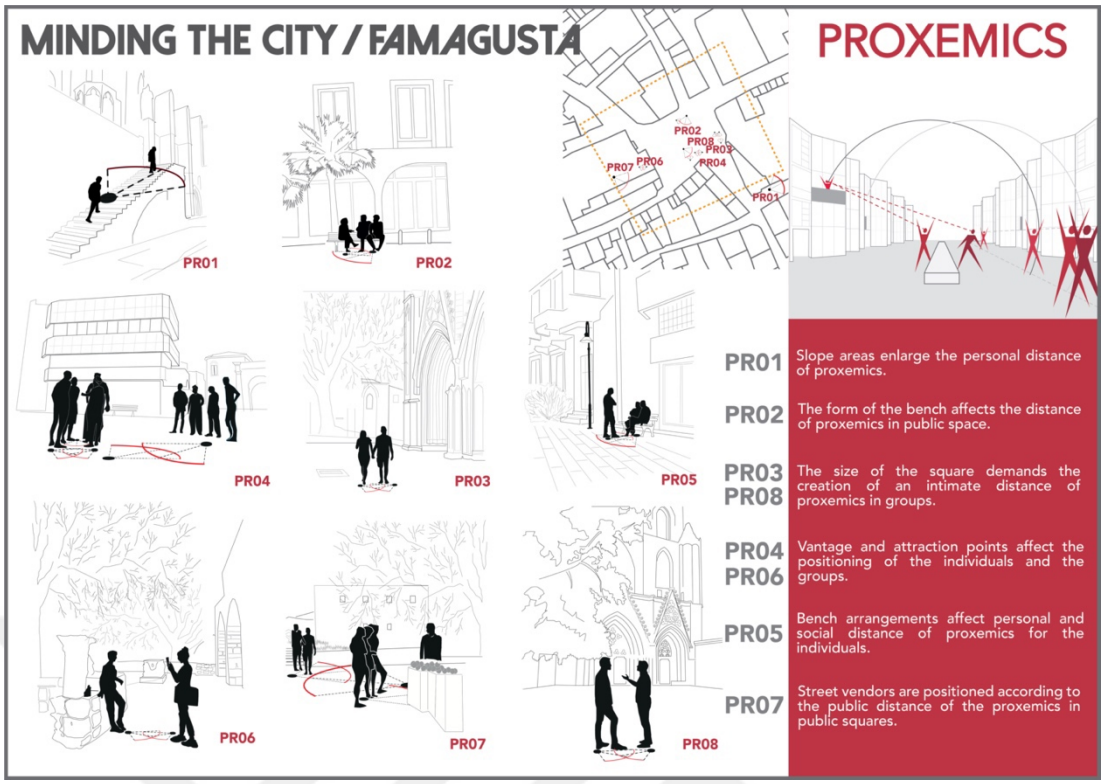


Figure 3.7 : The proxemics concept.

The results revealed that the arrangement of urban furniture, the size of the space, the topographic features of the space, the presence of attraction and vantage points, and the greenery affect the proxemic behavior of human beings. The form and the arrangements of the benches change the personal distance. At the same time, the size of the square may demand more intimate relations between the groups, altering social and public distancing. Additionally, it was observed and experienced that walking in the slope areas requires larger personal distancing. The presence of attraction and vantage points and the trees have the most significant impact on the human experience as distancing by creating gathering points.

3.4.6 Thigmotaxis

The boundaries of a space significantly influence human preferences for the experiential use of space. Kallai et al. (2007) identified thigmotaxis as *an essential element of spatial cognition and emotionally guided, safety-seeking behavior,* while Walz, Mühlberger, & Pauli (2016) associated thigmotactic behavior with *agoraphobia, a pathologic fear of open spaces, and anxiety sensitivity*. In architecture and urban studies, the edge effect, which has similar references to thigmotaxis, is identified as a preference for the use of urban space (Gehl, 2011). We studied the

concept by examining the floor coverings, borders, and vertical and horizontal edges of an urban setting. Figure 3.8 shows the thigmotaxis experiences of users in Namık Kemal Square.

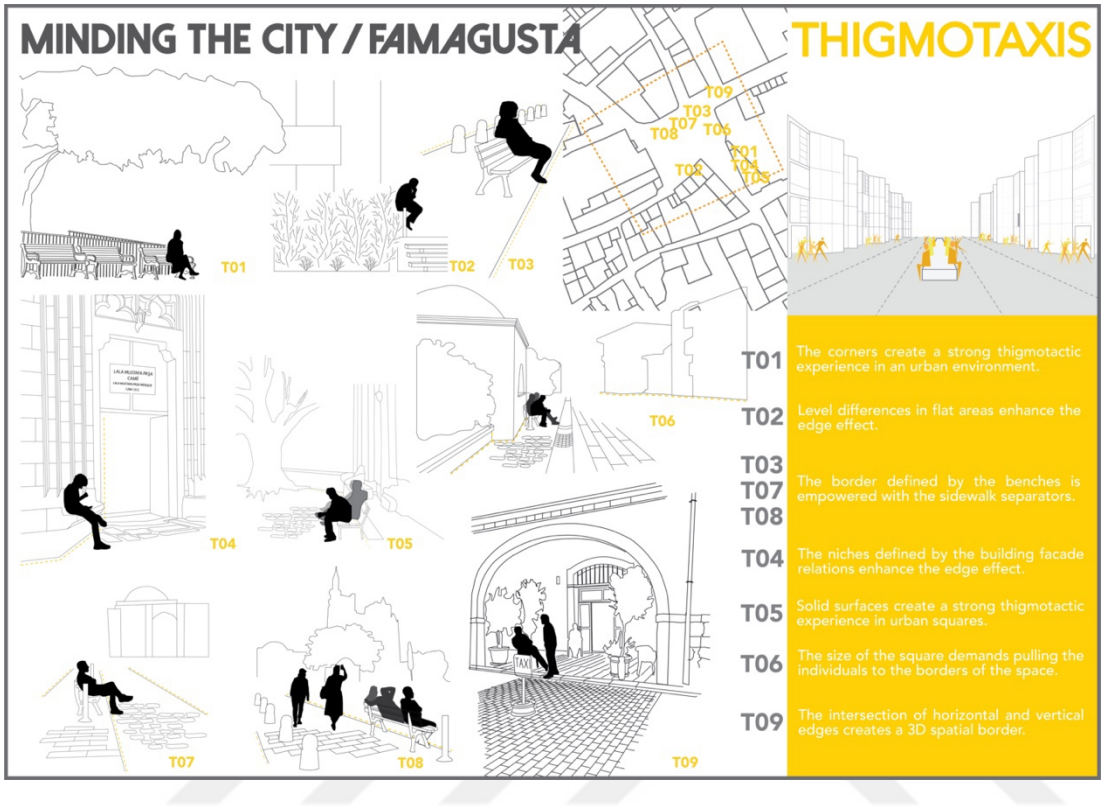


Figure 3.8 : The thigmotaxis concept.

The elements of space creating a thigmotactic experience vary from a niche on the building facades to the line on the street and the level and material differences on the floor and facades. The surface's solidness or transparency significantly impacts the thigmotactic experience. It was revealed that people prefer to sit and watch the square next to solid surfaces. In addition, coupling the thigmotactic elements of space, such as using intersected vertical and horizontal edges and repetitive bench arrangements with the sidewalk separators, intensifies the thigmotactic experience. Lastly, the size of the space stimulates people towards tactile stimuli, as proxemics tend to do. Therefore, it demands pulling individuals to the border of space.

3.4.7 Curvilinearity and rectilinearity

The quality of the contours of space affects the experiential use of an urban setting. In the present paper, interaction with the contours of space is studied with a specific interest in the curvilinearity and rectilinearity concepts. Bar and Neta (2007) found that people prefer everyday objects with curved contours over sharp-angled objects.

Additionally, Nanda et al. (2013) explored the impact of contours on emotions through the neuro-architecture paradigm with a particular interest in curves vs. sharp angles. After reviewing many studies concerning the impact of visual stimuli on the human brain, they proposed hypotheses on the impact of curvature as a visual property evoking emotional responses in the limbic system and affecting the individuals' emotional experiences. The people's interactions with the curved and sharp contours of space are shown in Figure 3.9.

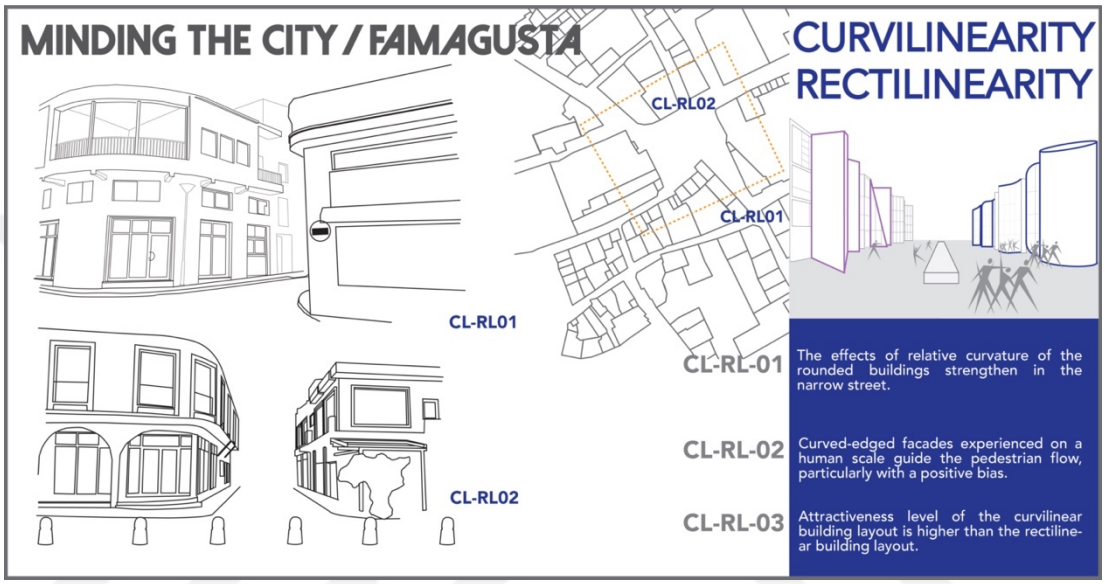


Figure 3.9 : The curvilinearity and rectilinearity concepts.

The curvilinearity and rectilinearity of space affect the users' movement and emotional states and the attractiveness level of that space. It was found that the curved elements of building facades experienced at a human scale significantly affect pedestrian preferences with a positive impact. Furthermore, the attractiveness level of curvilinear forms is higher than that of rectilinear ones. Additionally, the effect of curved shapes changes according to the relative distance. For example, it increases in the narrow streets.

3.5 Conclusion and Future Work

The present paper investigated the human experience in multiple urban settings by using the knowledge of the human brain to mind the city through new conceptualizations based on human evolutionary cognitive tendencies; biophilia, bilateral symmetry, mirror neurons, pareidolia, proxemics, thigmotaxis, curvilinearity, and rectilinearity. The insights of individuals on the conceptualizations concerning the

experiential use of urban settings were presented through an empirical inquiry. Therefore, the case study research design was developed and applied.

In this particular study, the knowledge derived from various disciplines was applied to the architectural and built environment studies to develop an experiential case investigating human experience as the individual human self, interpersonal human being, human-built environment interactions, and human-nature interactions. The shared behavioral patterns were explained and exhibited as statements converted into urban codes, which provide fundamental material for an enriched human experience in the built environment. The urban codes were presented as the final output of the fieldwork. Ultimately, the acquired knowledge applied to a theory-building structure expands the theory of human experience investigated through the idea of minding the city.

Our findings indicated that the human experience is mainly shaped by the shared behavioral patterns identified by the human evolutionary cognitive tendencies, whether consciously or unconsciously. It briefly means that people experience an urban setting by keeping the other people and the environmental features in mind and regulating their responses to them through the defined conceptualizations. Additionally, the awareness of the concepts creates an enriched and conscious experience that provides more immersed interaction with the urban phenomenon and results in higher recognition of the human experience. The impact of some concepts is more potent than others and easy to recognize. However, some concepts can only be perceived through the eyes of an outsider or through retrospective investigation of self-experience. For example, the biophilic tendencies of human beings are more apparent than all the other concepts, so the relationship with the natural elements is observed and experienced with full awareness.

Similarly, the concept of thigmotaxis has a strong influence on human beings. Participants both found and defined their interactions with the borders of space with clarity. Additionally, bilateral symmetry, curvilinearity, and rectilinearity concepts are easily perceived due to their clear visual cues and evaluated by their significant impact. However, recognizing the pareidolia concept increases with the raised awareness of participants; the more carefully they look around, the more faces they find in the built environment. On the other hand, the proxemic experience of individuals and groups is recognized both at the time of the experience and retrospectively. Observing and

defining proxemic tendencies in public space is complicated due to the possibility of creating biases in the interactions of familiar and unfamiliar individuals and groups. Finally, the concept of mirror neurons is mainly perceived by the retrospective investigation due to its highest abstractness level. The participants identified precise behavioral relations based on the imitation and the understanding of the behavioral patterns of individuals and groups. However, they had difficulty making sense of the data and expressing them as written statements. The discussions concerning this peculiar occasion suggested that empathizing with others and adapting to a specific environment might occur even before we intend to do.

In conclusion, minding the city improved the available knowledge of the human experience through the urban codes. It provided valuable insight into the investigation of the new conceptualizations that emerged in the neuro-architecture and cognitive architecture studies. Additionally, the study presented the evolutionary aspects of human experience in a new way by referring to generalizable patterns in the experiential use of urban settings through the human perceptual, cognitive, sensational, and emotional responses.

The idea of minding the city suggests an alternative way of reading the city through the knowledge of the human brain, which is still in its very early stages requiring lots of future work. Future studies should consider focusing on a single concept to study more deeply. However, developing a holistic view of human evolutionary cognitive tendencies in experiential and experimental studies should be a concern. Furthermore, the concept of mnemonics, which we mentioned in the pilot study but has not been studied yet, should also be investigated. Lastly, future studies should be developed with more trained participants through varied fieldwork.

[1] The term 'urban code' was first used by Mikoleit and Pürckhauer (2011) in the book Urban Code: 100 Lessons for Understanding the City, a set of written statements on the experiential use of an urban setting.

Overview

The human experience is a multifaceted phenomenon that can be studied at different levels. The expanding knowledge of the brain and mind primarily contributes to the studies on human experience and the experiential use of environmental settings. Minding the city prioritizes the human brain, mind, and psyche to study human experience specified by human evolutionary cognitive tendencies while expanding the available knowledge on the neuroscience of human experience from the points of individuals' insights. Furthermore, the new conceptualizations based on human evolutionary cognitive tendencies are investigated through an empirical inquiry contributing to neuro-architecture and cognitive architecture study fields.

The human experience is examined as individual human self, interpersonal human being, and through human-built environment interactions and human-nature interactions at self-reflective and observational levels. The shared behavioral patterns that occurred upon experiencing multiple urban settings were explained and exhibited as statements eventually presented as urban codes. The study's findings indicated that people experience an urban setting by keeping other people and the environmental features in mind and regulating their responses as our ancestors had done evolutionarily.

4. THE IMPACT OF URBAN GRAFFITI WITH FACIAL EXPRESSIONS ON HUMAN BEHAVIORAL AND EMOTIONAL RESPONSES IN A VR ENVIRONMENT[3]

4.1 Introduction

Human experience based on human-built environment interactions is one of the major topics to be investigated in understanding the influence of environmental features on human responses. Human-built environment interaction considers the human experience a multi-dimensional, multi-disciplinary, and multi-modal study of human responses to environmental stimuli. In the past several decades, developments in neuroscience and cognitive sciences have played a crucial role in understanding the impact of environmental features on the human experience, including behavioral, emotional, cognitive, and sensational dimensions. The present study investigates the human behavioral and emotional experiences based on human-built environment interaction with a specific interest in urban graffiti displaying fear and pleasure-inducing facial expressions.

Urban graffiti research has a long tradition of being studied by a wide range of disciplines, including social sciences, cultural studies, environment and behavior studies, psychology, anthropology, and most recently, neuroscience. Presently, the legitimacy of urban graffiti is accepted worldwide and has become an essential part of our urban lives. Additionally, a common consensus on the absolute impact of urban graffiti on the human experience, whether positive or negative, is established based on the extensive literature on the function, form, and politics of urban graffiti (Austin and Sanders, 2007; Coffield, 1991; McAuliffe and Iveson, 2011; Rasidah *et al.*, 2016; Rubin, 2015; Sajadzadeh *et al.*, 2017; Tokuda *et al.*, 2019).

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[3] This chapter is based on the following publication: Karakas, T., Dumlu, B.N., Sarıkaya, M.A., Yildiz Özkan, D., Yüksel, D., İnce, G. (2023). "The impact of urban graffiti with facial expressions on human behavioral and emotional experiences in a VR environment", Archnet-IJAR, Vol. ahead-of-print No. ahead-of-print. https://doi.org/10.1108/ARCH-03-2023-0087

Furthermore, urban graffiti is a multi-dimensional visual phenomenon with representational and non-representational features which potentiate an interaction between brain functioning and the built environment. As Kandel *et al.*, (2012) stated, human beings' visual experiences are object-centered based on the experience of complex visual components, associating them with past experiences. Therefore, urban graffiti's representational features have been considered a parameter for investigating human experience. In the scope of the study, the subject of urban graffiti is specified as emotionally charged facial expressions representing fear and pleasure-inducing facial elements to confront the lack of adequate research concerning the representational features of urban graffiti and their impact on human behavioral and emotional experiences. Fear and pleasure emotions are studied because they are primary emotions creating measurable bodily changes and behaviors (Kandel *et al*., 2012).

The research design is developed as a multi-method approach, applying a lab-based experimental research strategy. The experimental setting is a virtual reality (VR) environment created as a virtual urban space. The research equipment includes a mobile electroencephalogram (EEG) device, a Looxid Link device (URL), and a VR headset. The behavioral and emotional human responses concerning the representational features of urban graffiti are assessed objectively by measuring physiological variables and subjectively by measuring behavioral and self-report variables. Furthermore, correlational analyses between behavioral and emotional results are performed. The experimental procedure includes the baseline survey, VR experiment, and Self-Assessment Manikin (SAM) questionnaire. Systematic behavioral observation, EEG, and SAM data are collected during the experimental procedure and analyzed both individually and correlationally. Moreover, the study materials are prepared by selecting the proper fear and pleasure-inducing urban graffiti, which would be applied to the VR model, and by designing the VR model.

The paper is organized as follows. Section 2 covers the research background studies using fear and pleasure-inducing facial expressions as the representational features and multi-method approach examples using neuroscience research techniques. Section 3 discusses the research questions, and the formulated hypotheses are identified. Materials and methods are elaborated on in Section 4. The graffiti selection process and the design of the VR environment are indicated. Then, the experimental setting,

procedure, and equipment are introduced. Data collection and analysis techniques are also identified. In Section 5, the results are revealed and discussed, conforming to the hypothesis. Finally, in Section 6, the paper presents the contributions, limitations, and future studies as a conclusion.

4.2 Research Background

4.2.1 The use of urban graffiti displaying facial expressions

Most studies on urban graffiti are focused on explaining the presence of graffiti and the effect of the type of graffiti. However, the elements of urban graffiti significantly influence the human experience and require more detailed research due to their representational features (Mitschke *et al.*, 2017) and multidimensionality (Austin and Sanders, 2007). As human beings, we evolutionarily prioritize faces over other visual elements (Sussman and Hollander, 2015), and we have developed skills for face perceptions (Haxby *et al.*, 2000). Both evolutionarily and culturally, fearful facial expressions are considered dangerous environmental features (Darwin, 2004; Ekman *et al.*, 1969). Additionally, facial expressions are one of the most used stimuli sets in emotion studies (Adolph and Alpers, 2010; Adolphs, 2002; Lang *et al.*, 1993), which have been widely adopted in the study of human experience regarding emotions, behaviors, attention, engagement, and liking because of their distinct effect on the brain and behavior (Kim *et al.*, 2018; Leder *et al.*, 2013; Mitschke *et al.*, 2017; Mogg and Bradley, 2010; Sutton *et al.*, 2019; Vuilleumier, 2007).

Furthermore, neuroscience studies suggest that a larger human brain area is responsible for face recognition than recognition of any other visual objects (Kandel *et al.*, 2012). Besides, a fearful facial expression evokes a response even if it exists subliminally and is perceived unconsciously (Kandel *et al.*, 2012). Therefore, as an approach to investigating human-built environment interaction concerning human behavioral and emotional experiences, the present study uses urban graffiti displaying fear and pleasure-inducing facial expressions as the environmental stimuli.

4.2.2 The use of a multi-method approach for studying human experience

For decades, one of the primary research tools applied in the presence and effect of graffiti studies are self-reports, ethnographies, in-depth interviews, observations, and visual data collection, generally used to study cultural and social issues (Fransberg *et*

al., 2021). Besides, self-reports and observations are the most commonly used tools in studying human experience from the perspective of traditional architecture and environment and behavior studies. However, these tools have some weaknesses, such as the interruption of the flow of information, the cut-in on the continuous sampling of affective states (Coan and Allen, 2007), the attentional biases towards the reports (McNally, 1996), and distortions due to social stereotypes or personal defense or avoidance (Armony and Vuilleumier, 2013) encountered in self-reports, and the research biases and reliability problems affecting the observations directly (Sommer and Sommer, 2002). Therefore, to elaborate on human-built environment interactions regarding the human experience, a multi-method approach based on objective and subjective measurements, including physiological, observational, and self-reports, is applied in the present paper.

In recent years, there has been ever-evolving literature on using neuroscience approaches in architecture and built environment studies (Azzazy *et al.*, 2020; Higuera-Trujillo *et al.*, 2021; Karakas and Yildiz, 2020) that enables us to understand the human experience at psychophysiological and neural levels. The most recent researches include; investigating the impact of glass floors using a combined version of EEG, galvanic skin response (GSR), heart rate variability, eye-tracker, and a questionnaire (Erkan, 2021), the investigation of the human reactions toward different space geometries using EEG measurements (Shemesh *et al.*, 2017) and the combination of EEG, GSR and eye-tracking measures (Shemesh *et al.*, 2021); the evaluation of the impact of interior forms on emotions and the affective states of inhabitants using a virtual version of SAM questionnaire (Banaei *et al.*, 2020), and using mobile EEG (Hekmatmanesh *et al.*, 2019); the quantitative relations between geometric properties of rectangular rooms and the architectural experience using questionnaires and scaling techniques in VR technologies (Franz *et al.*, 2005). It is evident in the literature that the triangulation of the data through the multi-method approaches raises the study's reliability, objectivity, credibility, and validity.

Only a few studies have examined the impact of urban graffiti at physiological and neural levels. James and O'Boyle (2019) used functional magnetic resonance imaging (fMRI) and a questionnaire applied during the experiment via buttons to understand graffiti's negative impact on neighborhood safety evaluations. They investigated the impact of the presence of graffiti by applying a single form of graffiti to different

neighborhood scenes by leaving aside the elements of graffiti. Mitschke *et al.* (2017) used an eye-tracker coupled with rating procedures and questionnaires in a real-world setting with a follow-up session in a lab environment to examine the people's experience of sculptures and graffiti. They referred to the importance of using a multi-method approach as compensation for the limitations of each method.

Furthermore, employing VR technologies for a multi-method approach enables examining certain environmental features and modified versions with significant clarity and accuracy. VR is a potent tool for studying human behavior with the ability to create three-dimensional computer-generated environments that allow humans to perceive their surroundings as Cartesian reality, where people can move and perceive in 3D trajectories (Brooks *et al.,* 2019). As Dumlu (2020) explained, VR Head-Mounted Displays (HMDs) offer a more realistic and immersive digital experience than traditional computer modeling. By enabling users to see a digital representation of physical reality, VR HMDs go beyond the two-dimensional screen of a computer and allow users to experience a Virtual Environment (VE) with binocular vision that closely simulates real-world perception. Franz *et al*. (2005) identified that architectural research can be more empirical by using VR technologies with their flexibility of stimulation and easy-to-create controlled laboratory conditions while still providing a high degree of perceptual realism. In architecture and urban research fields, more researchers have focused on VR as a medium for conducting user studies, measuring perception of space or effects of architectural elements for both users and designers by applying empirical and experimental settings recently (Elver Boz *et al.,* 2022; Keshavarzi *et al.,*2021; Llorca-Bofi & Vörlander, 2021; Zhang *et al.,* 2021; Dumlu, 2020). Also, it is highlighted that VR has particular advantages with its immersive, interactive, multi-modal, multi-sensory ability to apply real-world features for neuroscience, psychology, and cognitive science research (Bohil *et al.,*2011; Loomis *et al.,*1999).

Therefore, the present paper applies a multi-method approach using a VR environment to create a coherent research design with controlled stimuli, aiming to conduct a focused investigation of human behavioral and emotional experiences with urban graffiti.

4.3 Research Questions and Hypotheses

In the present paper, the representational features of urban graffiti, identified as fear and pleasure-inducing facial expressions, are prioritized due to their significant impact on the human brain and responses. To investigate the human behavioral and emotional experiences that occurred upon encountering urban graffiti displaying fear and pleasure-inducing facial expressions, two research questions (RQs) are asked:

RQ1: Which behavioral responses occur upon encountering urban graffiti displaying fear and pleasure-inducing facial expressions?

RQ2: Which emotional responses occur upon encountering urban graffiti displaying fear and pleasure-inducing facial expressions?

RQ1 and **RQ2** are grounded on the impact of representational features of urban graffiti on human experience while furthering the inquiry by adding more dimensions, i.e. behavioral and emotional, and asking for an outcome regarding the human responses. **RQ2** also subsumes the contributions of neuroscience and cognitive science studies in understanding human emotional experiences objectively with the help of physiological measurements. Eventually, the answers to **RQ1** and **RQ2** will contribute to a better understanding the human-built environment interactions.

After completing the required literature research and preliminary study, the present study's hypotheses based on the research questions are formulated as follows:

H1: Urban graffiti's representational features impact human behavioral responses.

H1-1: The urban graffiti displaying fear-inducing facial expressions elicit a behavioral fear response.

H1-2: The urban graffiti displaying pleasure-inducing facial expressions elicit a behavioral pleasure response.

H2: Urban graffiti's representational features impact human emotional responses.

H2-1: The urban graffiti displaying fear-inducing facial expressions elicit an emotional fear response.

H2-2: The urban graffiti displaying pleasure-inducing facial expressions elicit an emotional pleasure response.

4.4 Materials and Methods

4.4.1 Participants

Fifty-four healthy volunteers (mean age= 22.7 years; range 18-55 years; 36% female, 64% male) participated in the experiment. The participants were recruited from Istanbul Technical University, including students and staff, with an e-mail invitation. A convenience sampling technique was applied to make accessing a broad range of groups easier due to gender, age, education level, and demography. All the participants reported no previous victimization experience, no visual impairment, and having normal vision (or corrected to normal). The local institutional ethics committee of Istanbul Technical University (2014/461) approved the experimental setup and protocols. Fifteen participants (10 men and 5 women) lacked complete data and were omitted; thus, 39 participants were included in the statistical results. The experimental procedure was introduced at the beginning of the process, and they were led to read and sign the consent form. When the instructions were clear to the participant, they were allowed to participate in the experiment.

4.4.2 Apparatus / Environmental stimuli

4.4.2.1 Graffiti selection

The urban graffiti used in the VR experiment were selected using several steps. First, the urban graffiti examples were manually collected via an image search on the web, which were selected according to their representational features, including fear and pleasure-inducing facial expressions, whether easily perceivable or subliminal. Secondly, an online survey including image selection and emotional state questionnaires was developed to select the urban graffiti that trigger intense emotional responses. Finally, the urban graffiti examples were presented randomly and without research bias.

The sample group consisted of 118 volunteering participants (mean age= 31.4 years; range 20-60 years; 47% women, 53% men). The students and the academic personnel of the authors' institutions were recruited through e-mail to become participants in this preliminary study. Before applying the questionnaire, an informed consent form was acquired from each participant. The questionnaire included (1) questions regarding image selection and the emotional state of the participant, which rate the facial

expressions in the given urban graffiti in terms of the fear and pleasure induction levels using a five-point Likert scale (1- not inducing, 3- neutral, 5- extremely inducing) and (2) demographic questions. Finally, 12 out of 21 urban graffiti following the survey results were selected shown in Figure 4.1. The weighted average of each graffiti's fear and pleasure induction rates was sorted in descending and ascending order, respectively. The urban graffiti examples were consistently labeled using the fear and pleasure emotion rates revealed from the survey results, as indicated in Figure 4.1. Thus, two identifiable categories, fear-inducing and pleasure-inducing urban graffiti, were created.

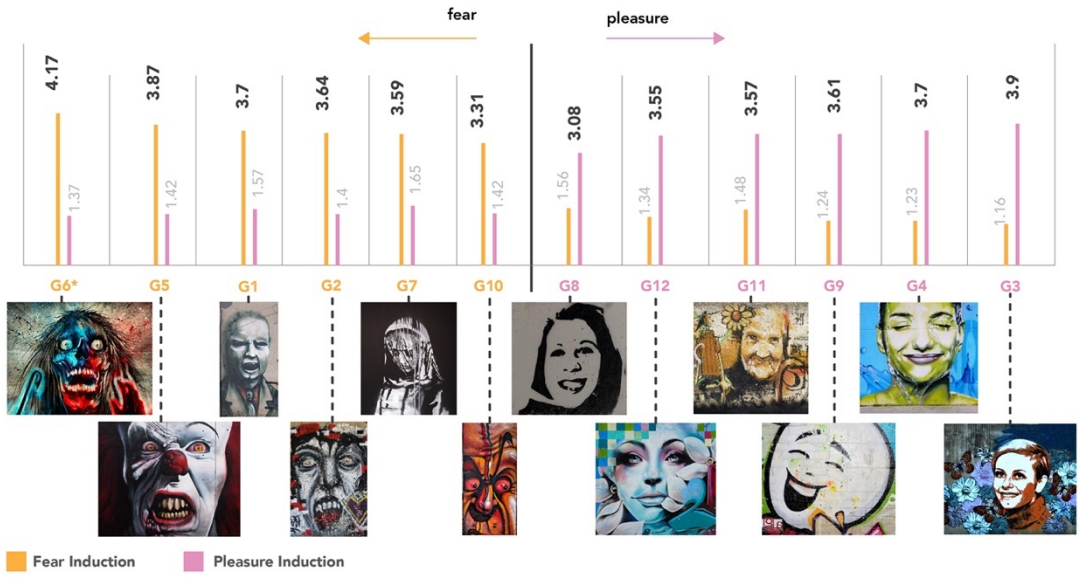


Figure 4.1 : The survey results .

Consequently, six urban graffiti with the highest induction rate of pleasure and six with the highest induction rate of fear were selected. The 12 chosen urban graffiti were integrated into the virtual urban model at the end of this screening procedure. The color scheme and the labeling system, e.g. G1, G2, etc., refer to the order of graffiti that the participants would encounter while walking in the virtual urban model.

4.4.2.2 Environmental modelling in VR technologies

VR technologies were employed as a medium for the experiment, and the experimental setting was designed as a virtual urban space specifically for the purpose of the present study. The virtual urban environment was modeled in Google Sketchup and uploaded to the VR headset via VRSketch.

The design process of the virtual urban model included several steps based on intense teamwork that contributed to creating a focused study on urban graffiti with an increased impact. First, the related literature was studied including the level of realism, using urban elements and social agents, and the application criteria of urban graffiti. According to Scurati *et al.* (2021), the level of realism in a VR environment depends on the purpose of the experience; providing a focused representation could create an experience with presence. Additionally, to create a real-life scale in a VR environment, designing depth perception facilitated by shape, size, volume, proportion, and scale refers to the level of realism (Paes *et al.*, 2023), even without building hyper-realistic characteristics as responsive agents (urban elements and social agents). Furthermore, as Shemesh *et al.* (2016) emphasized, isolating the desired variables by eliminating some properties of an environment is essential for conducting a controlled experiment and collecting accurate physiological data. Therefore, in the present study, the level of realism was provided by creating a real-life scale urban environment contingent upon the scale of applied urban graffiti with accurate distances, shapes, sizes, volumes, and proportions. Additionally, the VR environment was designed with the idea of how we encounter the facade-sized graffiti on blind walls sampling a not-real but precisely developed place with the appropriate street width and facade sizes in the virtual space.

Next, the design criteria of the VR model were specified, including the main characteristics of the urban environment and the application of urban graffiti, and applied to the VR model. As urban characteristics, 1) continuous courtyard patterns with greenery indicating non-pedestrian surfaces were created to provide dedicated spaces for encountering urban graffiti, 2) the building blocks were designed based on the morphological properties of building masses by disregarding colors, openings, and textures, 3) the orientation of building blocks was located shifted according to the placement of urban graffiti, 4) urban elements such as pavements, streetlights, urban furniture except trees were ignored, 5) social agents as humans were disregarded, and 5) daylight was used. Additionally, as application criteria of urban graffiti, 1) each graffiti was applied on surfaces invisible from the route unless reaching the exact location, 2) urban graffiti examples were displayed randomly to prevent creating predictable patterns of fear-inducing and pleasure-inducing stimuli, and 3) Each graffiti was placed on different surfaces of the building masses including left and right

sides, straight or perpendicular alignments of the route to create a surprise effect, shown in Figure 4.2.

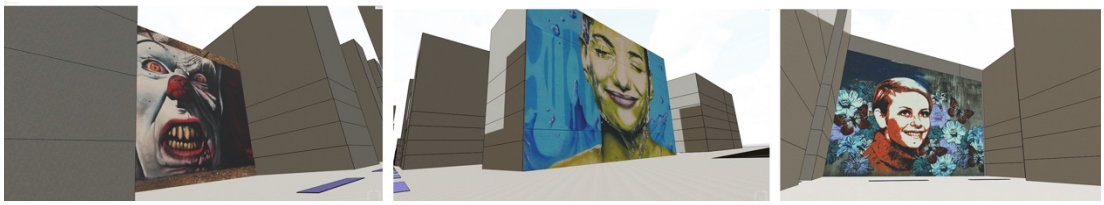


Figure 4.2 : Some exemplary scenes from the VR environment for G5, G4, and G3, respectively.

Finally, a pilot study was developed to test the VR environment using the research team as an expert group. A sampled VR experience from the study was prepared as shown in Figure 4.3 which indicated the walking area in detail. The narrowest pass between two buildings on the route was arranged from 10 meters to 20 meters, and the height of the building blocks was between 15 meters to 50 meters (this interval is accurate for urban dwelling settlements) to create a better real-life scale in width and length.

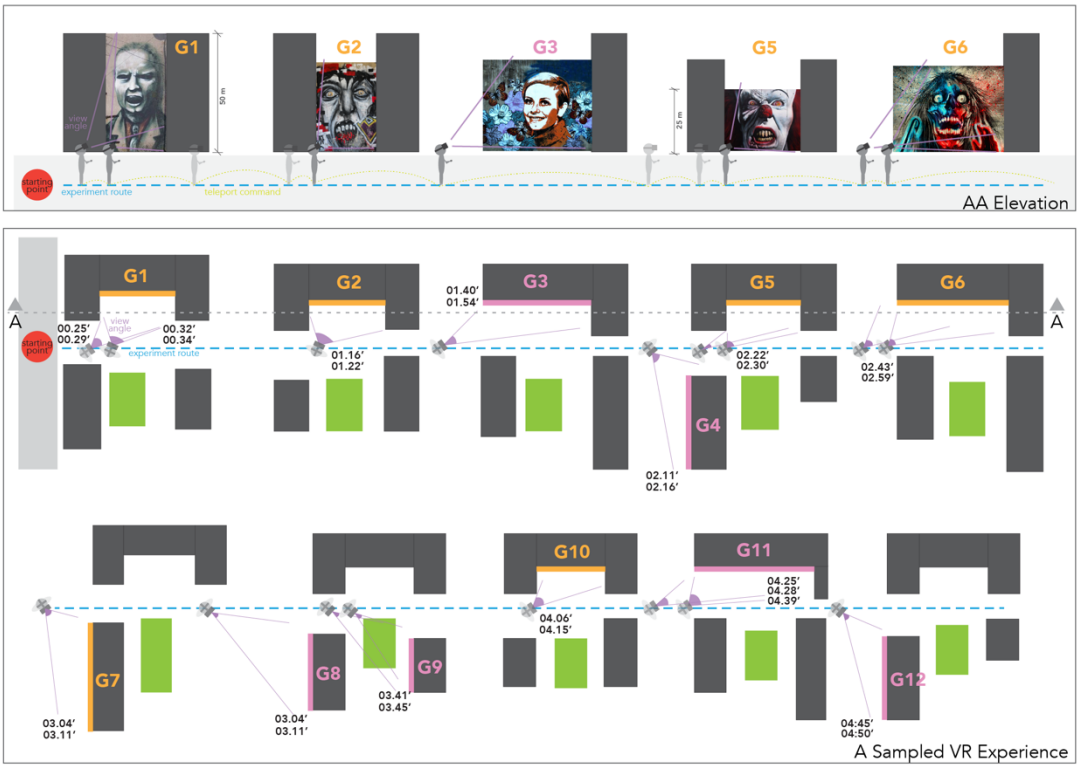


Figure 4.3 : A sampled VR experience.

Each participant, except for the model's designer, experienced the VR environment as it would be used in the main experiment (5 expert evaluations). The research team was

informed about the design criteria of the VR model and asked to evaluate the appropriateness of the criteria with the aim of the study. During the pilot study, for each participant, the total time spent in the model was calculated, and after the experiment, focus group interviews were developed to collect insights. The insights included removing the trees not to block the visibility of urban graffiti, creating better building orientations to improve the surprise effect, and limiting the total time spent by 5-7 minutes using a locomotion technique known as teleportation command in VR (based on the user's pace). Consequently, the final model emerged by applying the results of the pilot study.

The final model was 350m wide and 900m long, with a 180m wide and 800m long walking area. The aim of building a wider virtual model was when users saw through the voids between buildings; they could see building blocks that might improve the level of immersion. Figure 4.4 shows the detailed drawings of the VR model; Figure 4.4(a) the walkable area, the route length is 800m, Figure 4.4(b) the applied urban graffiti, Figure 4.4(c) the entire site plan drawing.

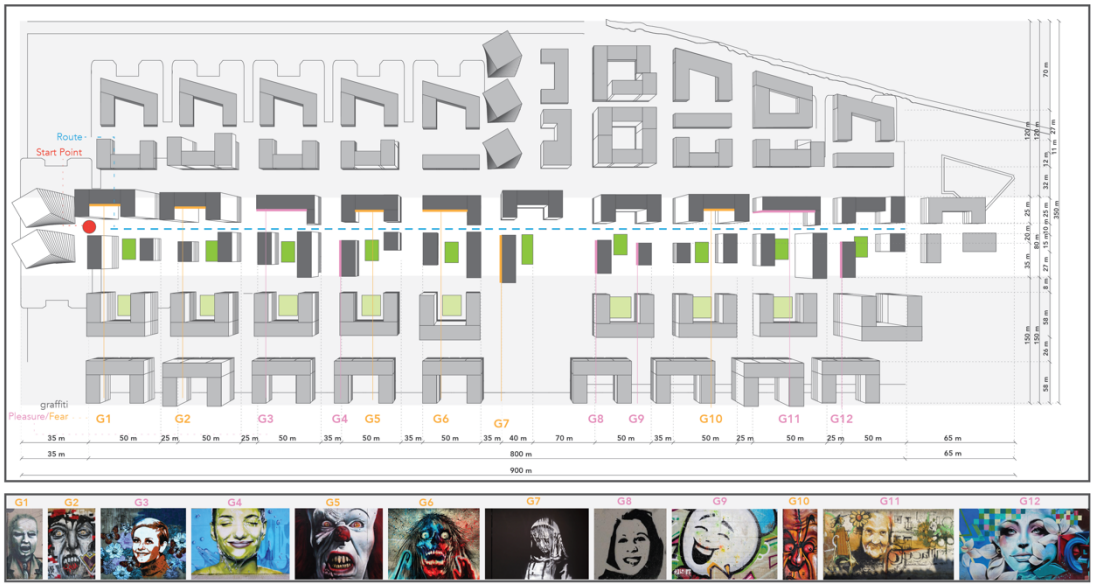


Figure 4.4 : The site plan of the environmental design.

4.4.3 Experimental setting and procedure

The experiments were carried out in the user experience (UX) lab of the Faculty of Computer and Informatics Engineering at Istanbul Technical University. An isolated room with the necessary free space for the VR setup (approximately 4 square meters) was prepared. The computer-based SAM questionnaires were applied in a separate

room to prevent unexpected encounters. The room and the devices used in the experiment were presented in Figure 4.5; Figure 4.5(a) the experimental setting, Figure 4.5(b) the VR headset (HTC Vive), and Figure 4.5(c) the mobile EEG device (the Looxid Link Package for Vive).



Figure 4.5 : The experimental setting and the devices worn by the participant.

The experiment was carried out according to a defined experimental procedure. The experimental procedure's schematic representation indicating each phase's duration was shown in Figure 4.6.

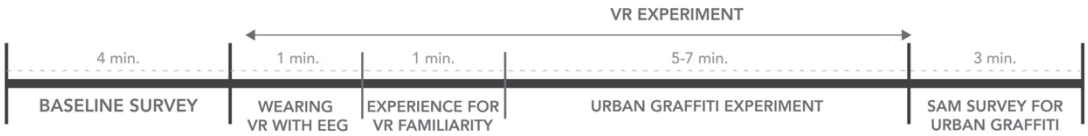


Figure 4.6 : The experimental procedure.

The experimental procedure started with the baseline survey, which was developed to decide on the proper participants and applied through the website (https://freeonlinesurveys.com/). The baseline survey gathered demographic information, as well as information about general health conditions, vision impairments, usage of stress-related medicine or treatment, drinking caffeinated

beverages, last night's sleep quality, and current stress levels for each candidate of the participant. Then, the proper participants were guided to the isolated room for the VR experiment. The participants were informed that their brain signals would be collected via a mobile EEG integrated into a VR headset; their eye, head, and virtual bodily movements would be recorded by collecting VR screen recordings; and the timing information about their looking towards graffiti would be noted to obtain the timestamps for the synchronizing the EEG data and VR screen recordings.

The VR experiment was designed as the main part that lasted approximately nine minutes in total. The participants were allowed to move their bodies freely without relocating them during that whole time. Furthermore, the participants were asked to walk using teleport and stay upright during the experiment to minimize the effect of any external stressors. After introducing the devices and the experimental setting, the participants were equipped with wearable devices and stayed equipped during the VR experiment.

First, the participant was virtually spawned in a three-dimensional room with a view for one minute to become familiar with the VR headset and teleportation. Afterward, the participant was allowed to roam freely until they felt relaxed in the virtual environment. Then, as the main part of the VR experiment, the participant experienced the virtual urban model displaying the selected 12 urban graffiti. The participant was placed at the route's starting point and told to follow the path on the ground using the teleportation technique, which allows virtual locomotion using the VR controller's trigger buttons. The participant was asked to look at the urban graffiti placed on the walls of the urban model for at least 3 seconds to gather consistent EEG data whenever they saw one. When the participant reached the end of the route, the session was finished, and the participant was unequipped.

Finally, the participant was taken into the complementary room to complete the SAM questionnaire when the VR experiment was over. After the participants were informed about the meaning of valence, arousal, and dominance value and how to rate a stimulus through the SAM scale, they reported their emotional experiences with the graffiti through the SAM questionnaire.

4.5 Data collection and analysis

4.5.1 Observational measurements

Behavioral observation is a commonly used tool for the study of the non-verbal actions of human beings. In the present paper, the participants' behaviors, including looking behaviors and bodily behaviors, were observed during the VR experiment, and the data was collected as VR screen recordings captured at eye level. Looking behaviors, following eye and head movements, and bodily behaviors, following bodily direction and movement, were considered indicators of the intentions to act of participants while experiencing a virtual urban environment. The content analysis method was applied in the study of those video recordings. Using content analysis for making valid inferences from the video recordings provided a systematic and objective plan to construe the participant's behavioral experiences with urban graffiti.

The content analysis process included defined procedures and rules (Downe-Wamboldt, 2009). First of all, the video recordings were divided into fragments showing the actions of participants with the encountered graffiti. Those fragments were examined as the unit of analysis for answering **RQ1** and studying **H1**, i.e. **H1-1**, and **H1-2**. Secondly, looking behavior and bodily behavior categories were created based on the participant's behavioral patterns, and a coding scheme was suggested for quantizing the qualitative, human behavior (Saldana, 2016). The coding system was based on the occurrence of specific behavioral patterns, indicating significant attributes of the individuals' behavioral experiences. For this study, two proficient individuals were defined as coders who developed and applied a particular protocol of coding to translate the behaviors into measurable data after watching the 39 individuals' video recordings in detail. Finally, the coders quantified the coding system by determining the absence and presence of actions in the video recordings' fragments (absence=0, presence=1).

The coding protocol included the first cycle coding system and evaluation criterion for the coding scheme. The first cycle coding system had *general look, single glance, scanning, fixation, focus on a face, focus on teeth, focus on eyes, and walk-and-watch* and *stop-and-watch behaviors.* After thoroughly reviewing all the recordings a second time, some codes were eliminated and consolidated due to inadequate data. In the second cycle coding system, *general look, scanning, fixation, and focus on facial*

features behaviors were applied to study the looking behavior category, and *walk-and-watch and stop-and-watch* behaviors were examined under the bodily behavior category.

The evaluation criteria were defined and the data content was analyzed according to the following rules in the **"***looking behavior***"** category: *The general look* was evaluated as a fixed look lasting less than 5 seconds; **scanning** behavior was observed when the participants scanned the urban graffiti with directional and continuous head movements without eye fixation. *Fixation* behavior was based on the number and duration of fixations and assessed through two behavioral patterns; the former was a fixed look that occurred during scanning behavior and the duration of fixation was more than 3 seconds, and the latter was the same as a general look but the duration of the fixation was more than 5 seconds. The *focus on facial feature* behavior was a specialized fixation behavior in that the participant fixated look on facial features for more than 3 seconds. Additionally, the participants moved through the virtual VR model using the VR controller's trigger buttons, which enabled us to recognize the bodily direction and movement in the "*bodily behavior***"** category; the *walk-and-watch* and *stop-and-watch* behaviors were perceived by the distinct attributes of varied walking preferences of the participant.

Furthermore, an analysis based on the duration of "*looking behaviors***"** was done for each graffiti, including average looking durations and minimum and maximum times spent. The participants' looking durations were calculated by measuring the time difference between the beginning and the end of the experience for each urban graffiti. Finally, the quantified data was used to perform correlational analyses between behavioral and emotional results to understand the impact of urban graffiti on human experience thoroughly.

4.5.2 Electroencephalogram (EEG) measurements

EEG measurement is widely used in investigating the brain's electrical activity during an event affecting the body-brain systems. EEG devices vary in their connection types (wired and wireless), electrode connection (wet and dry), number of channels, and electrode placements (Soufineyestani *et al.*, 2020). This study uses the Looxid Link package for Vive, which is developed as an integrated accessory device for the HTC Vive VR Headset. The device is wireless, dry, and has six channels. Additionally, it

offers several advantages throughout the experiment, such as using a unified device that removes mobility and artifact problems (Sá *et al.*, 2020). The device collects delta (1-3 Hz), theta (3-8 Hz), alpha (8-12 Hz), beta (12-38 Hz), and gamma (38-45 Hz) brainwaves from the brain's prefrontal area through the AF3, AF4, AF7, AF8, Fp1, and Fp2 channels with a sampling rate of 500 Hz (Costa *et al.*, 2021). Additionally, the device tracks EEG signals with yielding attributes like attention, relaxation, and brain balance.

In analyzing the data, the focus was laid on measuring the changes in brain activity in response to exposure to urban graffiti with facial expressions in a VR environment, emphasizing the emotions of fear and pleasure. Furthermore, EEG data were also used to explore the correlations between observational and EEG data. The "average band powers" were calculated as the area under Welch's periodogram, which was the sum of the areas of parabolas fitted to the power spectral density estimates of each frequency band. This measure estimated the power of each frequency band in the EEG signals. The Looxid Link SDK was used to obtain these estimates. Additionally, RStudio was used as the development environment for implementing the data analysis and visualization scripts. The R language and its associated statistical packages were used for preprocessing EEG signals, such as removing artifacts, applying filters, segmenting the signals, and performing correlational analysis.

4.5.3 Self-Report measurements

The studies on emotional experience include a broad range of models, including discrete and dimensional perspectives over the years (Armony and Vuilleumier, 2013). In the scope of the study, a dimensional model called the Circumplex Model of Affect was applied to measure and evaluate participants' emotional experiences. James Russell (1980) introduced the Circumplex Model of Affect as a two-dimensional model that posits the emotion on a circumplex or two orthogonal axes. The first axis refers to the valence axis, which represents pleasantness/unpleasantness, pleasure/unpleasure, or good feeling/bad feeling, whereas the second axis refers to the arousal axis representing exciting/relaxing or active/calming dimensions. Russell and Mehrabian (1977) established the third dimension as a third axis referring to the dominance that represents the level of control categorized as dominance/submissiveness or dependent/independent. The Self-Assessment Manikin

(SAM) scale was used to develop a dimensional study of human emotions, which was developed by Bradley and Lang (1994) to evaluate participants' emotional responses through valence, arousal, and dominance dimensions. Our study utilized a computer-based seven-point scale, as shown in Figure 4.7.

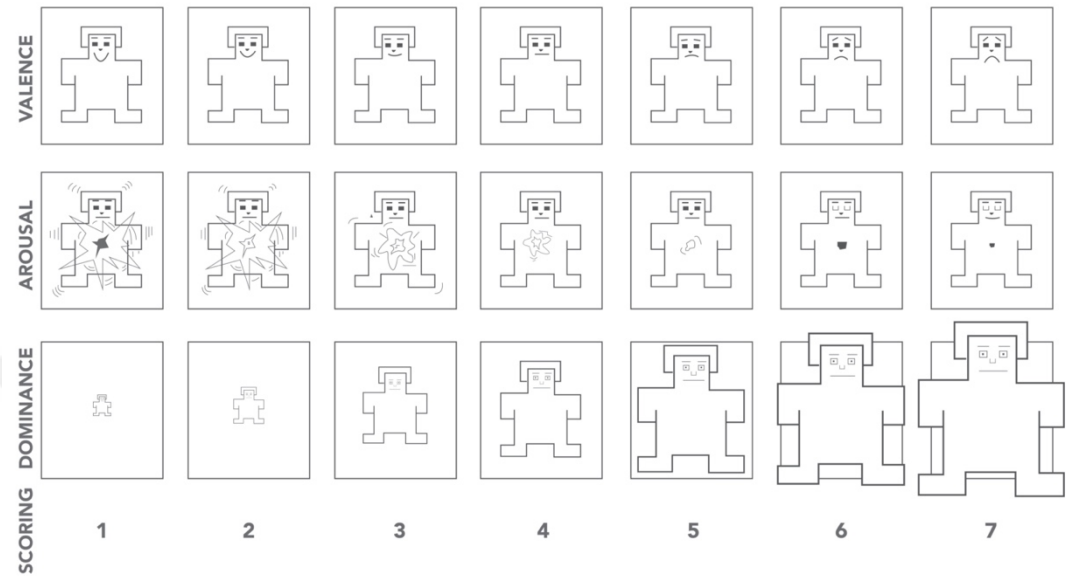


Figure 4.7 : Seven-point scale SAM questionnaire, adapted from Bradley and Lang (1994)'s five-point scale SAM questionnaire.

The SAM scale was applied as the post-questionnaire not to distract the participants' attention during the VR experiment and to acquire precise physiological and behavioral data. In addition, the SAM values were measured to understand the subjective experience of individuals for each urban graffiti on the pleasure, arousal, and dominance scale and to perform statistical analysis to examine the relationship between SAM values and the human fear and pleasure response. The analysis starts with the recorded SAM responses on each of the 12 urban graffiti for each participant, which was documented in a spreadsheet. Next, each urban graffiti's mean valence, arousal, and dominance scores were calculated and discussed. Additionally, the correlations between observational measurements and SAM scores were also inquired.

4.6 Results and discussion

4.6.1 Behavioral evaluation

This section studies human behavioral experiences regarding urban graffiti displaying fear and pleasure-inducing facial expressions. We expect to find answers for **RQ1** and

validate **H1**, including **H1-1** and **H1-2**, through the results of the observational analysis.

The content analysis results revealed from the behavioral observations are displayed in Table 4.1, representing both the code-wise and the cumulative presence values according to the proposed coding system for each graffiti. Additionally, the highest values for each code and the highest cumulative values are highlighted to indicate the dominant behavior for each graffiti. Besides, Table 4.1 shows the findings in two groups, fear and pleasure-inducing, to find polarities or commonalities in the participants' behaviors.

Table 4.1 : The summary table of the content analysis.

		LOOKING BEHAVIOR				BODILY BEHAVIOR		CUMULATIVE PRESENCE VALUE
	Graffiti / Coding Scheme	General Look	Scanning	Fixation	Focus on Facial Features	Walk-and-watch	Stop-and-watch	
Fear-Inducing Urban Graffiti	G1	23	18	16	**11**	0	1	69
	G2	22	26	27	8	0	3	**86**
	G5	24	22	24	5	1	**5**	82
	G6	15	**30**	**30**	5	0	4	**84**
	G7	**34**	10	27	2	0	0	73
	G10	17	**33**	**35**	15	0	1	101
	SUM	135	**140**	**159**	**46**	1	**14**	**101**
Pleasure-Inducing Urban Graffiti	G3	24	26	21	**6**	**6**	0	
	G4	30	12	16	0	2	0	83
	G8	32	7	19	0	1	0	60
	G9	33	7	23	0	4	0	59
	G11	14	**33**	23	**6**	3	1	67
	G12	**33**	8	24	0	0	12	80
	SUM	**166**	93	127	12	**16**		67

First, for the fear-inducing urban graffiti category, *scanning, fixation*, and *focus on facial features* are found as the dominant "looking behavior", while *stop-and-watch* behavior is revealed as the dominant "bodily behavior". In detail, G1 has the second highest value for focus on facial features, which is over 10. G5 has no dominant behavior considering looking behavior but gets the highest degree of stop-and-watch behavior. G6 is coded with the highest scanning and fixation behavior and relatively higher stop-and-watch behavior. G7 has an idiosyncratic situation among the fear-inducing urban graffiti, which is observed to be significantly higher with the general look behavior. Finally, G10 has the highest scanning, fixation, and focus on facial feature values. Additionally, G2, G6, and G10 get the highest cumulative presence values of the 12 urban graffiti, creating a recognizable behavioral relation based on fear-related features.

Second, for the pleasure-inducing urban graffiti category, the *general look* is identified as the dominant "looking behavior", while *walk-and-watch* behavior is found to be the dominant "bodily behavior". G3 has no dominant behavior in looking behavior category but gets the highest value of walk-and-watch behavior. G4, G8, G9, and G12 are significant with general look behavior values. G11 is recognized as significantly higher for scanning behavior. G3 and G11 have a unique situation among the pleasure-inducing urban graffiti by being coded with a relatively higher focus on facial feature values.

Finally, the findings about the looking durations are shown in Table 4.2, representing the average, minimum, and maximum looking durations. Again, the highest average looking durations and the maximum time are highlighted.

Table 4.2 : The findings of looking duration analysis.

	G1	G2	G3	G4	G5	G6	G7	G8	G9	G10	G11	G12
Avg	5.74	**9.28**	**9.85**	6.85	**8.62**	**11.20**	8.23	6.29	7.10	**10.18**	**10.14**	7.87
Min	3	4	4	3	4	3	3	2	2	2	2	2
Max	12	17	**21**	15	**22**	**23**	13	13	14	**20**	**20**	16

One significant result revealed from the findings is that there is no coherence between the looking duration and the emotions elicited by the urban graffiti. G2, G3, G5, G6, G10, and G11 have the highest average of looking durations. Additionally, G3, G5,

G6, G10, and G11 have the most extended looking durations, over 20 seconds. This might be associated with a higher engagement level due to the urban graffiti's visual quality as colors, alignment, number, and arrangement of elements regardless of elicited emotions. Lastly, the findings show that a dramatic change occurs between each graffiti's minimum and maximum values. Therefore, it is inferred that each user has their own behavioral patterns. The users who tend to spend a rather short time engaging in urban graffiti have lower looking durations for each graffiti. In contrast, users who tend to spend a rather long time engaging in urban graffiti also have higher looking durations for each graffiti.

The findings of the observational study support **H1** considering the impact of urban graffiti's representational features on human behavioral responses. Besides, **H1-1** claims that "the urban graffiti displaying fear-inducing facial expressions elicit a behavioral fear response." Supporting **H1-1**, it is revealed from the observational results that "stop-and-watch" behavior is a fear response that occurs encountering urban graffiti displaying fear-inducing facial expressions in the bodily behavior category. In the literature, freezing is one of the most common fear expressions (Adolphs, 2002). Therefore, the "stop-and-watch" behavior has been interpreted as a freezing behavior that suspends the experience for a while. Additionally, the results show that "stop-and-watch" behavior is mainly coupled with the "fixation" behavior, concentrating on "focus on facial features" in the looking behavior category, which might be rooted in our past experiences considering fearful facial expressions as threats.

H1-2, which also states, "The urban graffiti displaying pleasure-inducing facial expressions elicit a behavioral pleasure response," is supported by the observational results. It is revealed that "walk-and-watch" behavior occurs in the bodily behavior category encountering the pleasure-inducing urban graffiti. It is mostly experienced with "general look" behavior in the looking category. "Walk-and-watch" behavior has been interpreted as a pleasure response occurring in a relaxed and comfortable situation and not interrupting the experience, representing a sustained response pattern.

4.6.2 Emotional evaluation

The human emotional experiences based on encountering urban graffiti displaying fear and pleasure-inducing facial expressions are studied through psychophysiological

evaluations based on EEG analysis and SAM evaluations. As a result, we expect to find answers for **RQ2** and validate **H2, H2-1**, and **H2-2**.

4.6.2.1 EEG results

The Looxid link provides both mind index (attention and relaxation values) and feature index (average band powers of the delta, theta, alpha, beta, and gamma brainwaves from the AF3, AF4, AF7, AF8, Fp1, and Fp2 channels) results. Figure 4.8 presents the constructed box plot representing the patterns of attention and relaxation values obtained during looking at the 12 urban graffiti. Additionally, a paired t-test was used to determine whether there was any difference between individuals' graffiti-based relaxation and attention levels; that is, whether the fear and pleasure-inducing urban graffiti examples significantly impacted the human emotional experience. One significant result is that the coherence between attention and relaxation level of the brain is found to be different for fear-inducing urban graffiti except for G7; conversely, there is no coherence at all for pleasure-inducing urban graffiti. As seen in Table 4.3, G7 (Relaxation, Median=0.50, SD=0.21, min=0.09, max=0.91; Attention, Median=0.46, SD=0.22, min=0.12, max=0.94) demonstrates high relaxation and low attention levels unlike other fear-inducing urban graffiti. Considering the fear-inducing urban graffiti examples, the relevant sample t-test showed that there was a significant area of difference in relaxation and attention levels for G1, G2, and G10 (paired t-test, $p<0.001$), a relatively substantial range for G5 (paired t-test, $p=0.022$) and G6 (paired t-test, $p=0.002$). Considering the pleasure-inducing urban graffiti examples, G4 (paired t-test, $p=0.013$) and G9 (paired t-test, $p=0.001$) were moderately significantly different in relaxation and attention levels. At the same time, for G8, G11, and G12, there were no significant statistical differences in relaxation and attention levels.

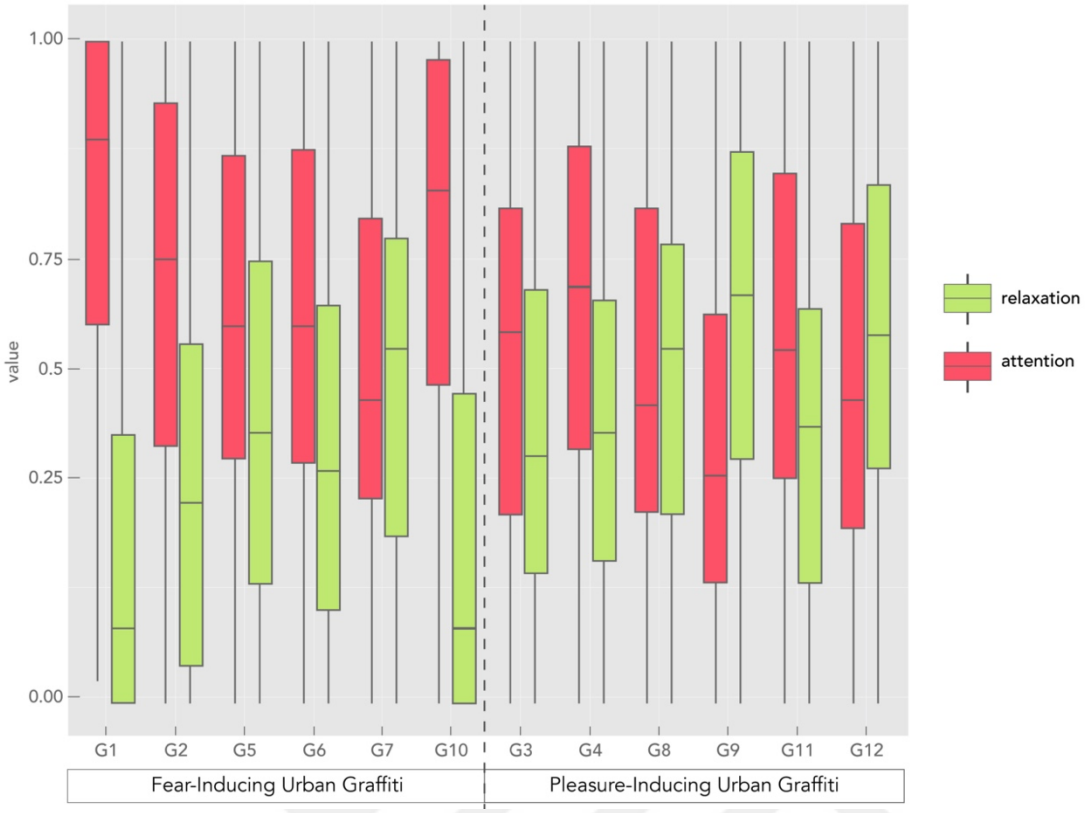


Figure 4.8 : EEG mind index results.

Table 4.3 : Graffiti-based findings for relaxation and attention levels. SD= Standart deviation; Min= Minimum Values; Max= Maximum Values.

		RELAXATION				ATTENTION			
		Median	SD	Min	Max	Median	SD	Min	Max
Fear-Inducing Urban Graffiti	G1	0.14	0.21	0.01	0.78	0.81	0.21	0.18	0.99
	G2	0.31	0.21	0.00	0.75	0.66	0.23	0.15	1.00
	G5	0.37	0.23	0.06	0.95	0.60	0.22	0.05	0.99
	G6	0.35	0.21	0.06	0.86	0.63	0.22	0.09	0.95
	G7	0.50	0.21	0.09	0.91	0.46	0.22	0.12	0.94
	G10	0.17	0.25	0.01	0.96	0.74	0.24	0.02	0.95
Pleasure-Inducing Urban Graffiti	G3	0.36	0.24	0.00	0.91	0.54	0.24	0.12	1.00
	G4	0.44	0.22	0.09	0.90	0.64	0.23	0.05	0.95
	G8	0.53	0.21	0.12	0.96	0.48	0.21	0.05	0.82
	G9	0.62	0.22	0.10	0.96	0.36	0.20	0.04	0.83
	G11	0.43	0.21	0.07	0.83	0.54	0.22	0.07	0.91
	G12	0.55	0.23	0.05	0.88	0.47	0.21	0.09	0.86

CONFIDENCE LEVEL (95.0 %)

The feature index results are represented through the frequency band powers; however, no significant results have been revealed for identifying the emotional experiences of individuals. This result supports the study of Bekkedal *et al.* (2011), which stated that identifying the neural representations of emotional processes might not be possible by the EEG signals recorded from the brain's surface.

Regarding **RQ2** and **H2**, the EEG results support our hypothesis, considering the impact of urban graffiti's representational features on emotional responses. The

findings of EEG measurements provide substantiating results for **H2-1**, which claims that "the urban graffiti displaying fear-inducing facial expressions elicit an emotional fear response." However, no evidence exists to verify **H2-2**, which claims that "The urban graffiti displaying pleasure-inducing facial expressions elicit an emotional pleasure response." It is inferred from the results that emotional fear response was identified with high attention and low relaxation levels. Furthermore, the contributions of using physiological data in identifying emotional responses are yielded.

4.6.2.2 SAM results

The SAM results are represented through the mean values of the 12 urban graffiti shown in Figure 4.9 in a 3D plane.

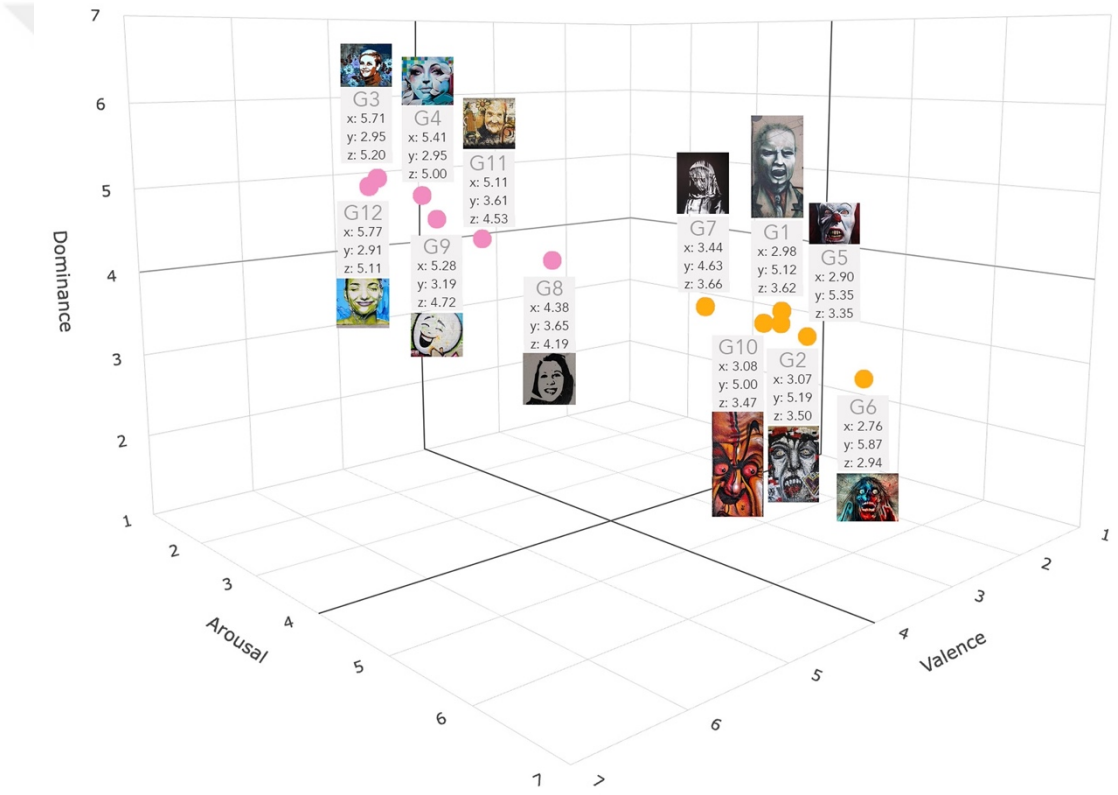


Figure 4.9 : Mean valence, arousal, and dominance results using the SAM scale.

G1, G2, G5, G6, and G10, which are fear-inducing urban graffiti examples, are scored rather lower in valence, higher in arousal, and lower in dominance. On the other hand, G3, G4, G8, G9, G11, and G12, which are pleasure-inducing urban graffiti examples, are scored fairly higher in valence, lower in arousal, and relatively higher in dominance which is over 4. The polarity of the valence and arousal values occurs as expectedly. For the dominance values, it is revealed that the dominance scores have a significant

negative association with arousal scores while having a relatively positive association with valence scores. The findings align with Bradley and Lang (1994)'s findings that state a positive relation between pleasure and dominance scores.

Following the findings of the SAM questionnaire, **RQ2** is answered, and **H2** is validated. Supporting **H2-1**, the fear-inducing urban graffiti elicits an emotional fear response characterized by high arousal, low valence, and low dominance. On the other hand, the pleasure-inducing urban graffiti elicit an emotional pleasure response characterized by low arousal, high valence, and high dominance supporting the **H2-2**.

4.6.2.3 Correlational results

This section illustrates the correlation between human behavioral and emotional responses regarding urban graffiti displaying fear and pleasure-inducing facial expressions. This correlation study investigates whether there is a significant relationship between the behavioral and emotional results to reveal the impact of urban graffiti displaying fear and pleasure-inducing facial expressions. We expect to support **H1**, including **H1-1** and **H1-2**, and **H2**, including **H2-1** and **H2-2**, through the correlation results of behavioral and emotional data.

In performing correlational analyses, the observational results, the graffiti-based average of the EEG results, and the graffiti-based average of the SAM scale results were used. A Pearson correlation test was computed in RStudio, and the ggcorplot package in R language was used for visualizing the correlations. In the graphs, the number and color in each block determined the correlation value. The red coloring identified the positive correlations, while the blue coloring identified the negative correlations. Additionally, values with a p-value of more than 0.05 were excluded from determining the impact of urban graffiti on behavioral and emotional experience, represented by the boxes marked with a cross.

The correlation between observational and EEG results is shown in Figure 4.10 An opposition between relaxation and attention values was found, as expected, and it was found that all the variables of observational measurements have significant relationships with relaxation and attention values except for fixation behavior.



Figure 4.10 : The correlational analysis of observational and EEG results.

Regarding **H1**, including **H1-1** and **H1-2**, and **H2**, including **H2-1**, the correlation between observational and EEG data results supported the findings of observational and emotional evaluations. The "general look" and "walk and watch" behaviors being identified as behavioral pleasure responses, as claimed in Section 5.1, **H1-2**, were negatively correlated with attention values being identified as emotional fear-response, as found in Section 5.2.1, **H2-1**. Furthermore, the highest correlation coefficient is indicated for "focus on facial features" behavior which is positively correlated with attention. Supporting **H1-1** and **H2-1,** "focus on facial features" and "attention" were the attributes characterized by the fear response, as stated in Sections 5.1 and 5.2.1.

The correlations between observational and SAM results are shown in Figure 4.11. All the variables have a significant relationship. However, the highest correlation coefficient was found between valence and arousal values and the bodily behavior category (walk and watch, stop and watch).



Figure 4.11 : The correlational analysis of observational and SAM results.

Regarding **H1**, including **H1-1** and **H1-2**, and **H2**, including **H2-1** and **H2-2**, the correlation between observational and SAM data results supported the results of behavioral and emotional evaluations. The "general look" and "walk and watch" behaviors were positively correlated with valence and dominance values while

negatively correlated with arousal values, along with the findings in Sections 5.1 and 5.2.2, supporting **H1-2,** and **H2-2.** Additionally, "stop and watch" and "focus on facial features" behaviors were positively correlated with arousal values while negatively correlated with valence and dominance values which agreed with the findings in Sections 5.1 and 5.2.2, supporting **H1-1, H2-1.**

4.7 Conclusion, Limitations, and Future Works

The present study examined the impact of urban graffiti displaying fear and pleasure-inducing facial expressions on human behavioral and emotional responses. The study's multi-method approach, applying a lab-based experimental research strategy using a VR environment, was based on subjective and objective assessments of human responses. Physiological, behavioral, and self-report measurements were used in behavioral and emotional evaluations, contributing to the literature on human-built environment interactions and urban graffiti by adding the representational features of urban graffiti as a parameter for investigating human experience in the built environment.

The results of the present study answered the research questions and verified the hypotheses: 1) the findings of the present paper indicate that the representational features of urban graffiti significantly impact human behavioral and emotional experiences producing specified behavioral and emotional responses (**RQ1, H1** and **RQ2, H2**). Additionally, according to the results in Tables 1,2,3, and Figures 8,9,10,11 it is found that fear responses (**H1-1, H2-1**) and pleasure responses (**H1-2, H2-2**) have apparent patterns. Based on the systematic observations, the behavioral evaluations reflect that a behavioral fear response elicited by the urban graffiti displaying fear-inducing facial expressions is identified with "scanning", "fixation", and "focus on facial features" in the looking behavior category and "stop-and-watch" behavior in the bodily behavior category. On the other hand, a behavioral pleasure response elicited by the urban graffiti displaying pleasure-inducing facial expressions is characterized by the "general look" in the looking behavior category and "walk-and-watch" behavior in the bodily behavior category.

The emotional evaluations were done by EEG and SAM measurements. According to the EEG results, the emotional fear response elicited by the urban graffiti displaying fear-inducing facial expressions is associated with high attention and low relaxation

levels. At the same time, no response pattern is detected for the emotional pleasure response elicited by the urban graffiti displaying pleasure-inducing facial expressions. Regarding the SAM results, the emotional fear response is identified by high arousal, low valence, and low dominance. In contrast, the emotional pleasure response is characterized by low arousal, high valence, and high dominance.

The present study has limitations based on the technical experimental parameters. Due to using a 6-channel mobile dry-EEG device collecting brain signals from the surface, the emotional experience of individuals was not able to be precisely studied at the neural level based on frequency band powers, even though it was assumed that the mobile EEG was adequate to reach new knowledge based on the feature index. Therefore, the mind index data was used in identifying emotional experiences. Additionally, some difficulties occurred in assessing looking behavior from the VR recordings, such as capturing the fixations. Therefore, the coding scheme of the observational study indicating the focus on the eye and the focus on teeth were consolidated as a focus on facial features in the second cycle coding scheme.

As a future work, a detailed investigation focusing on the identification of emotional experience at neural levels will be carried out with a technically improved experimental setting, including an improved EEG and an eye tracker. Additionally, machine learning model generation techniques regarding emotion recognition would be developed for further studies. In the end, to understand the potential of the VR environment, a variety of elements which are social agents, interactive urban features, natural elements, and daylight, will be implemented in the experimental procedure as variables to measure their effects on the human experience.

In conclusion, the research has suggested valuable results for understanding human behavioral and emotional experiences based on encountering the fear and pleasure-inducing urban graffiti examples. The study's practical implications, which means the operationalizations of the resulting evidence and the studied hypotheses, may contribute to the urban design processes. Urban graffiti becomes one of the crucial urban design elements that impact the human experience requiring consideration of the representational features. Moreover, the legislators and the regulators of the design disciplines may benefit from the findings of the present research in the application of graffiti examples in the urban environment.

Overwiew

The developments in neuroscience and cognitive sciences enable architectural researchers to study the human experience beyond traditional architectural research strategies by enriching the field through multi-disciplinary, multi-dimensional, and multi-modal research designs. Human experience based on human-built environment interactions has come to be studied at psychophysiological and neural levels.

The impact of urban graffiti on the human experience is one of the ongoing architectural research problems with a long tradition. However, adding the representational features of urban graffiti as a parameter of human behavioral and emotional experience is a fresh approach to urban graffiti studies. A multi-method approach is conducted to design a controlled study using a lab-based experiment research strategy in a VR environment. Observational, psychophysiological, and self-report measurements provide comprehensive data to understand human behavioral and emotional responses toward fear and pleasure-inducing urban graffiti. The study's findings indicate that behavioral and emotional fear and pleasure responses have apparent patterns that provide valuable insight into the evidence-based and research-based architectural design processes and understanding of the neuroscience of human experience.

5. DISCUSSION AND IMPLICATIONS

The thesis explored the neuroscience approach in architecture with a specified interest in the neuroscience of human experience and developed an architectural research framework for the neuroscience of human experience. Three intensive studies were conducted addressing the aim and objectives of the thesis through multidisciplinary, multidimensional and multimodal approach. The studies are presented as individual works throughout the thesis.

In the discussion part, the three papers' research design, processes, features, findings, and results were interpreted and discussed to a greater extent, seeking answers for the aims and objectives of the thesis. First, the summary of the theoretical and empirical findings was presented as an overarching conceptual framework indicating the theoretical, methodological, and practical contributions of the three papers to the neuroscience approach in architecture. Second, the theory of human experience investigated through the three papers was discussed to build new knowledge on the neuroscience of human experience. Ultimately, the architectural research framework for the neuroscience of human experience was presented.

5.1 Summary of Theoretical and Emprical Findings

In Chapter 2, we aimed to frame the state of the intersection between architecture and neuroscience. The review primarily contributed to the theoretical and methodological perspectives by crossing the disciplinary knowledge of architecture and neuroscience. Therefore, a conceptual framework for the neuroscience approach in architecture was produced to find common grounds for future studies.

The findings of the first paper were identified as; theoretically, the conceptual framework of the neuroscience approach in architecture was revealed. The emerging and developing concepts were categorized under overlapping, similar and different concepts. Additionally, the experimental studies were examined individually due to

the empirical nature of the neuroscience knowledge. The emerging and developing concepts were extracted in relation to the human experience, environmental features, and measurement techniques. It was revelaed that most concepts have been investigated through theoretical studies but have not been verified by experimental studies. Furthermore, the experimental studies are growing fragmentedly and isolated from each other. It was revealed that the study field has excellent potential to bridge scientific knowledge with the human experience, including human perception, cognition, behavior, emotion, feeling, and sensation in architecture and the built environment. However, the potential is accompanied by gaps and challenges. The gaps occur mainly between the theoretical and experimental studies regarding the investigation of concepts developed in theoretical studies through experimental studies. One of the challenges is formulating testable hypotheses in experimental studies, which requires a reductionist approach to designate a well-defined architectural research problem. Finally, the practical implications of the study area were identified as evaluating the performance of an existing built environment, providing evidence-based design decisions, and improving the quality of human lives and society.

Methodologically, the methods and techniques used at the intersection of architecture and neuroscience studies were extracted from the literature covering the classification of environment and behavior, neuroscience research methods and techniques, and the newly developed digital tools. Furthermore, the challenges of the study field based on methodological issues were presented. It was revealed that the technical issues, which are using the correct integrated collaborative devices, collecting clean and accurate data, managing the collected data, and interpreting the organized data in a meaningful way, shape the methodological approaches. Additionally, contrived settings such as laboratories and VR studios were defined as preferable experimental settings to natural settings because of the difficulty of controlling the effect of external stimuli during the experiment.

In Chapter 3, following the findings of the first paper, we explored the new conceptualizations that emerged at the intersection of two fields based on human evolutionary cognitive tendencies; biophilia, bilateral symmetry, mirror neurons, pareidolia, proxemics, thigmotaxis, curvilinearity and rectilinearity. The second paper mainly contributed to the theory of the human experience through the perspectives of

the neuroscience approach in architecture. It provided insights into neuro-architecture and cognitive architecture studies. Additionally, taking the information gathered through the senses and processed in the human brain as the primary concern in understanding human experience has contributed to the reading the city studies in architecture which is based on the empirical inquiry of individual human experience. Methodologically, a traditional research method, which was qualitative research applying a case study strategy, was used in the study of the newly developed theoretical framework. Such an approach has shifted the subject of traditional methods from the environment features to the human being experiencing an environment.

The findings indicated that individuals respond to their environment through shared behavioral patterns, which are similar to identified human responses by the concepts of human evolutionary cognitive tendencies, consciously or unconsciously. Furthermore, those shared behavioral patterns showed that people experience an urban setting by keeping other people and the environmental features in mind and regulating their responses accordingly. Additionally, the awareness of the concepts creates an enriched and conscious experience that provides more immersed interaction with the urban phenomenon and results in higher recognition of the human experience. Another finding of the paper indicated that the evolutionary aspects of human experience could be presented as generalizable patterns through the subjective investigation of the human responses and applied to a theory-building structure expanding the neuroscience of human experience. In the end, the shared experiences were explained and exhibited as statements converted into urban codes.

In Chapter 4, we investigated the human behavioral and emotional experiences based on human-built environment interaction with a specific interest in urban graffiti displaying fear and pleasure-inducing facial expressions. The third paper mainly contributed to the literature on human-built environment interactions and urban graffiti by adding the representational features of urban graffiti as a parameter for investigating human experience in the built environment. Additionally, the paper expanded the available knowledge on the neuroscience of human experience. Methodologically, systematic observations, EEG and SAM data were studied individually and correlationally that contributed to the use of neuroscience approach in architecture by adding a multi-disciplinary and research-based lens to architecture. Additionally, the study's multi-method approach, applying a lab-based experimental research strategy

using a VR environment, was contributed to subjective and objective assessments of human responses.

The results of the third paper answered the research questios and verified the hypotheses: 1) the findings of the present paper indicate that the representational features of urban graffiti significantly impact human behavioral and emotional experiences producing specified behavioral and emotional responses (**RQ1, H1** and **RQ2, H2**). According to the results, it is found that fear responses (**H1-1, H2-1**) and pleasure responses (**H1-2, H2-2**) have apparent patterns. Based on the systematic observations, the behavioral evaluations reflect that a behavioral fear response elicited by the urban graffiti displaying fear-inducing facial expressions is identified with "scanning", "fixation", and "focus on facial features" in the looking behavior category and "stop-and-watch" behavior in the bodily behavior category. On the other hand, a behavioral pleasure response elicited by the urban graffiti displaying pleasure-inducing facial expressions is characterized by the "general look" in the looking behavior category and "walk-and-watch" behavior in the bodily behavior category.

The emotional evaluations were done by EEG and SAM measurements. According to the EEG results, the emotional fear response elicited by the urban graffiti displaying fear-inducing facial expressions is associated with high attention and low relaxation levels. At the same time, no response pattern is detected for the emotional pleasure response elicited by the urban graffiti displaying pleasure-inducing facial expressions. Regarding the SAM results, the emotional fear response is identified by high arousal, low valence, and low dominance. In contrast, the emotional pleasure response is characterized by low arousal, high valence, and high dominance.

5.2 The Neuroscience of Human Experience

The neuroscience of human experience refers to the theoretical and practical implications of Chapters 3 and 4.

The neuroscience of human experience investigates the human experience as a holistic matter of fact based on the information gathered through the senses and processed in the brain. It can be studied at the psychophysiological and neural levels based on unconscious human experience and at self-reflective and observable levels through the individuals' insights, mainly conscious expressions of human experience. In the scope

of the study, the human experience is considered as an individual human self and interpersonal human being, and through the human-built environment and human-nature interactions.

The neuroscience of human experience offers a significant opportunity to acquire theoretical knowledge with methodological advancements and practical purposes. The findings of Chapter 3 and Chapter 4 advanced the knowledge available on the neuroscience of human experience by producing transferable knowledge and insights. The findings of Chapter 3 and Chapter 4 are indicated in Table 5.1

Table 5.1 : The neuroscience of human experience.

	CHAPTER 3
INDIVIDUAL HUMAN-SELF (self is mentioned as the subject of experience)	**Biophilia:** 1) the opportunity to turn inward for ***self-reflection*** and thus provide an individual experience of the human self.
INTERPERSONAL HUMAN BEING	**Mirror Neurons:** 1) people tend to ***duplicate*** the behavior displayed by other people, 2) people ***imitate*** the actions of other people, and 3) people ***orient*** their actions by understanding others' actions and intentions. **Proxemics:** 1) human regulates their interpersonal distancing according to the arrangement of ***urban furniture***, the ***size*** of the space, the ***topographic features*** of the space, the presence of ***attraction*** and ***vantage points***, and the ***greenery*** effect.
HUMAN-BUILT ENVIRONMENT INTERACTIONS	**Bilateral Symmetry:** 1) enhanced by perceiving a building from a ***distance*** surrounded by a symmetrically ordered urban landscape using the ***same symmetry axis***, the repetition of horizontal and vertical ***sub-symmetries*** even in the absence of complete symmetry, and the ***sharpness*** of architectural elements, 2) weakens by the lack of ***differentiation*** in color, size, and shape in the buildings' layouts and facades. 3) the symmetrical building enclosing a public space becomes an attraction point. **Pareidolia:** 1) the participants look for not only ***facial features*** but also ***facial expressions***, which impact their ***emotional experiences***, 2) looking for pareidolic features creates a ***positive*** environmental experience, 3) the identification of pareidolic elements only appears in the case of perceiving a ***clear facial expression***, 4) the ***multilayered*** elements of building facades enhance the pareidolia effect. **Proxemics:** 1) The form and the arrangement of the ***benches*** change the personal distance while the ***size*** of the square may demand more intimate relations between the groups, altering social and public distancing, 3) The presence of ***attraction*** and ***vantage*** points and the ***trees*** create gathering points. **Thigmotaxis:** 1) people prefer to sit next to the ***solid surfaces***, 2) the size of the space stimulates people towards ***tactile stimuli,*** and 3) coupling the thigmotactic elements of space intensifies the thigmotactic experience. **Curvilinearity and rectilinearity:** 1) the curved elements of building facades experienced at a human scale affect ***pedestrian preferences*** with a ***positive*** impact, and 2) the effect of curved shapes increases in ***narrow streets***.

Table 5.2(continued): The neuroscience of human experience

HUMAN-NATURE INTERACTIONS	**Biophilia:** 1) humans prefer to be close to natural elements such as ***greenery, sunlight, water,*** and ***animals*** for sitting, resting, and gathering individually and in groups, 2) the multisensorial dimension of human experience becomes highlighted with the ***sounds of birds***, the ***smell of flowers,*** and the ***tactility of plant tissues.***
	Proxemics: 1) walking in the ***slope areas*** requires larger personal distancing, and 2) the presence of the ***greenery*** features offer distancing by creating gathering points.
	CHAPTER 4
HUMAN-BUILT ENVIRONMENT INTERACTIONS	**Behavioral Fear Response**
	Observational:"Stop-and-watch" behavior in the bodily behavior category, the "fixation" behavior, concentrating on "focus on facial features" in the looking behavior category.
	Behavioral Pleasure Response
	Observational:"Walk-and-watch" behavior in the bodily behavior category, the general look" behavior in the looking category.
	Emotional Fear Response
	EEG: High attention, low relaxation levels
	SAM: High arousal, low valence, and low dominance
	Emotional Pleasure Response
	EEG: No evidence exists
	SAM: low arousal, high valence, and high dominance
	Correlations between observational and EEG results:
	The highest correlation coefficient is indicated for "focus on facial features" behavior which is positively correlated with attention (FEAR RESPONSE)
	The "general look" and "walk and watch" behaviors negatively correlated with attention values (PLEASURE RESPONSE)
	Correlations between observational and SAM:
	The "general look" and "walk and watch" behaviors were positively correlated with valence and dominance values (PLEASURE RESPONSE) while negatively correlated with arousal values (FEAR RESPONSE)
	"Stop and watch" and "focus on facial features" behaviors were positively correlated with arousal values (FEAR RESPONSE) while negatively correlated with valence and dominance values (PLEASURE RESPONSE)

The findings of the second paper presented in Chapter 3 expanded the theory of new conceptualizations based on human evolutionary cognitive tendencies while elaborating the neuroscience of human experience from the perspectives of the individual's insights. Human experience was investigated as an individual human self and interpersonal human being, and through human-nature and human-built environment interactions.

In the third paper, the results of the studied hypotheses provided evidence and factual findings on human behavioral and emotional responses based on human-built

environment interactions at self-reflective, observable, and psychophysiological levels that mainly contributed to understanding the neuroscience of human experience.

Human experience subsumes all the human responses toward environmental stimuli, including the sensory, cognitive, behavioral, and emotional. The insights of brain studies contribute to understanding human responses through neural mechanisms objectively; on the contrary, architectural studies provide information for the individual's subjective experience, which are the neural mechanisms' behavioral outcome. Both neuroscience and architectural knowledge are crucial for understanding the neuroscience of human experience.

5.3 Developing the Architectural Research Framework for the Neuroscience of Human Experience

The architectural research framework for the neuroscience of human experience was developed and presented as the outcome of the thesis. It is an answer to *how architects can work with this new knowledge of brain function?* The framework was based on not only the inferences, the hows, whats, and whys that showed up during the thesis research process but also the existing literature.

Table 5.3 shows the identified elements of architectural research framework for the neuroscience of human experience.

Table 5.3 : An Architectural Research Framework for the Neuroscience of Human Experience.

THE NEUROSCIENCE OF HUMAN EXPERIENCE	
Types of Human Experience: Individual human self – Interpersonal human being – Human-built environment interactions – Human-nature interactions **Levels of Human Experience:** Self-reflective – Observable – Psycho-physiological - Neural	
ARCHITECTURAL RESEARCH FRAMEWORK FOR THE NEUROSCIENCE OF HUMAN EXPERIENCE	
THEORY	**Research Paradigm:** Constructivism, Positivism, Pragmatism, Post-Positivism **Research Domain:** Architecture, Neuroscience, Neuro-architecture, Cognitive Archietcture, Environment and Behavior, Informatics, Cognitive Science **Research Concepts:** Behavioral Experience, Emotional Experience, Cognitive Experience, Sensational Experience **Research Variables:** Built Environmet/Architectural, Behavioral, Self-report, Psychphysiological, Neural Structures/Circuits **RESEARCH QUESTIONS & FORMULATING HYPOTHESES**
METHOD	**Research Design:** Qaulitative, Quantitative, Multi/Mixed Method **Research Strategy:** Case Study, Experimental **Research Method:** Observational, Self-Report, Archival, Mapping, Psychophysiological, Neuroimaging, Crowdsourcing Techniques, Wearable Devices, Virtual Reality (VR), Augmented Reality (AR) Technologies
PRACTICE	**Operational Outcome:** Empirical findings, resulting evidences, facts, tested hypotheses **Research & Design Collaboration:** Evidence-Based Design, Research Based Design, Science Informed Design

The theory refers to the philosophical assumptions on architectural research design frameworks and the theoretical approaches for the neuroscience of human experience in architecture. This twofold theoretical approach was studied through four elements

of inquiry: 1) Research paradigm, 2) Research domain, 3) Research concepts, and 4) Research variables. Research paradigm is the broadest term referring to the philosophical position, worldview, Creswell (2003)'s research approach, or Groat & Wang's (2013) system of inquiry. Positivism, post-positivism, anti-positivism, intersubjectivity, constructivism, naturalism, and emancipatory (Groat & Wang, 2013; Salama, 2019; Sattrup, 2012) are some of the most mentioned systems of inquiry applied to architectural studies in terms of ontological (what is knowledge or nature of reality) and epistemological (how we know it) interpretations. Research paradigm is not necessarily explicit in every research, but an assumption on the nature of the reality and generated knowledge exists in essence. The research domain includes identifying related disciplinary knowledge to clarify the research context and the audience. Research concepts refer to the primary research theme to which the research will eventually contribute. Zeisel (2006) identifies the role of developing concepts as ordering information and organizing study findings. Research variables include the designation of the dependent and the independent variables based on the disciplinary knowledge domains. The theory enables the researcher to ask the right research questions by creating a systematic link between architectural and neuroscience knowledge Afterward, the four elements of inquiry will eventuate with developing research questions and formulating hypotheses.

The methodology refers to the multidisciplinary, multidimensional, and multimodal research methodologies, including the disciplinary approaches of architecture, environment and behavior, neuroscience, and cognitive sciences. The methodology applies the overall research procedure or plan to explaining the process of studying a research problem, phenomenon, or hypothesis. The neuroscience of human experience can be investigated on multiple levels; self-reflective, observable, psychophysiological, and neural, requiring varied methodological approaches. The methodological elements of inquiry are identified as 1) Research design, 2) Research strategy, and 3) Research method.

The research design is a commonly used terminology in studying a research framework that refers to the broadest research procedure. Qualitative and quantitative duality is the most used research design; mixed-method perspectives are added to those research approaches (Creswell, 2003). The combined use of qualitative and quantitative methods is termed mixed or multi-methods in the literature (Groat & Wang, 2013).

The research design guides the research strategy and research method. Research strategy is a mode of inquiry that draws a plan for the research process, such as an experiment, case study, or survey research. Additionally, the research strategy includes the decision on the research setting. Research methods are the most detailed action plan referring to data collection, measurement techniques and tools, and analysis.

The practice refers to the operationalization of resulting evidence of the empirical inquiries and the studied hypotheses for the architectural, environmental, and landscape designers and the legislators and regulators of the design disciplines. This relationship between research and design is identified as the Operational Outcome and Research and Design Collaboration. The operational outcome of the research is based on the empirical findings, resulting evidence, facts, and tested hypotheses of the research. The study's outcome produces research-based knowledge, evidence, generalizable assumptions, and patterns. The research and design collaboration contributes to evidence-based, research-based and science-informed design approaches. In recent years, the crucial role of architectural research as a knowledge-building activity for architectural design practice has been noticed. Applying research-based design knowledge to the architectural profession is spreading vigorously worldwide, eventuating architectural research as a professional path. There are firms to provide consultancy and architectural research support teams based on the information gathered through neuroscience, cognitive sciences, and other human sciences. This evolving profession uses information for the sake of a design environment regarding the demands of that architectural space. It is called research-based, evidence-based, science-informed design to which neuro-architecture belongs.

5.3.1 The implementation of the architectural research framework for the neuroscience of human experience

The architectural research framework for the neuroscience of human experience was applied to Chapter 4 which was traced in detail below. Table 5.4 shows the sampled framework.

Table 5.4 : The sampled architectural research framework for the neuroscience of human experience.

The impact of urban graffiti with facial expressions on human behavioral and emotional experiences in a VR environment

Research Paradigm: Positivist (Objective, External but knowledge is complex, iterative and interconnected)

Research Domain: Architecture, Neuroscience, Environment and Behaviour, Cognitive Sciences, Neuro-architecture

Research Concepts: Human -Built environment interaction (as a kind of human experience) – Behavioral and Emotional Human Experience (Behavioral Fear/Pleasure Response, Emotional Fear/ Pleasure Response)

Research Variables:

Built Environment Variables -independent-	**Psychophysiological Variables - dependent-**	**Behavioural Variables -dependent-**	**Self-report Variables -dependent-**
Urban Graffiti	EEG signals	VR Screen Recordings	SAM questionnaire
Facial Expressions: Fear-inducing, Pleasure-inducing	Feature Index:Alpha, Beta, Gamma, Theta, Delta Mind Index: Attention - Relaxation	Looking Behavior Virtual Bodily Behavior	Arousal - Valence - Dominance

Experimental Setting: VR environment (virtual urban space)

Research Questions:
RQ1: Which behavioral responses occur upon encountering urban graffiti displaying fear and pleasure-inducing facial expressions?
RQ2: Which emotional responses occur upon encountering urban graffiti displaying fear and pleasure-inducing facial expressions?

Formulating Hypotheses:
H1: Urban graffiti's representational features impact human behavioral responses.
H1-1: The urban graffiti displaying fear-inducing facial expressions elicit a behavioral fear response.
H1-2: The urban graffiti displaying pleasure-inducing facial expressions elicit a behavioral pleasure response.
H2: Urban graffiti's representational features impact human emotional responses.
H2-1: The urban graffiti displaying fear-inducing facial expressions elicit an emotional fear response.
H2-2: The urban graffiti displaying pleasure-inducing facial expressions elicit an emotional pleasure response.

Research Strategy: Multi-Method Approach

Research Method: Experimental Research (Lab-based)

Measurement Techniques and Tools:

Psychophysiological M.	Observational M.	Self-Report M.	Digital Tools
EEG Signals	VR Screen Recordings	SAM Questionnaire	VR Technologies

Table 5.3 (continued) : The sampled architectural research framework for the neuroscience of human experience.

Results:
Behavioral Fear Response Observational:"Stop-and-watch" behavior in the bodily behavior category, the "fixation" behavior, concentrating on "focus on facial features" in the looking behavior category. **Behavioral Pleasure Response** Observational:"Walk-and-watch" behavior in the bodily behavior category, the general look" behavior in the looking category. **Emotional Fear Response** EEG: High attention, low relaxation levels, SAM: High arousal, low valence, and low dominance **Emotional Pleasure Response** EEG: No evidence exists, SAM: low arousal, high valence, and high dominance **Correlations between observational and EEG results:** The highest correlation coefficient is indicated for "focus on facial features" behavior which is positively correlated with attention (FEAR RESPONSE) The "general look" and "walk and watch" behaviors negatively correlated with attention values (PLEASURE RESPONSE) **Correlations between observational and SAM:** The "general look" and "walk and watch" behaviors were positively correlated with valence and dominance values (PLEASURE RESPONSE) while negatively correlated with arousal values (FEAR RESPONSE) "Stop and watch" and "focus on facial features" behaviors were positively correlated with arousal values (FEAR RESPONSE) while negatively correlated with valence and dominance values (PLEASURE RESPONSE)
Operational Outcome: The representational features of an urban graffiti have impact human behavioral and emotional experiences An urban graffiti displaying fear-inducing facial expressions stimulates fear response An urban graffiti displaying pleasure-inducing facial expressions stimulates pleasure response **Research and Design Collaboration** Not proposed

In Chapter 4, we searched for objective and external knowledge based on the impact of urban graffiti on human behavioral and emotional experience by applying a multi-method approach. The multi-method approach contained qualitative and quantitative methods using objective and subjective measurements and tools. As researchers, we kept ourselves stand-off from the research problem. However, while considering the possible research questions, we predicted some probabilities for the potential emotional and behavioral responses of representational features of urban graffiti and the research setting. Then, we formulated them as testable hypotheses accordingly. Finally, we designed the study method based on those predictions and probably unintentionally directed the participants' attention. Therefore, we stayed somehow associated with the research problem.

The study was a lab-based experiment using psychophysiological, observational, and self-report measurement techniques and employing VR technologies as a research setting. A neuroscience approach is naturally reductivist, simplifying the variables that limited study with the defined representational features of urban graffiti applied in a contrived environment. During the investigation, objective and subjective data were collected.

In analyzing the data, using all the objective data as it is, there are always multiple ways of associating the data with the research problem that direct the researchers' standpoint to more meaningful and logical associations. Furthermore, we drew insights into the human experience by interpreting the subjectively collected data, which naturally blurred the borders between the researchers and the research. As seen, the research process was highly iterative. Therefore, considering these inferences, the study can be classified under the positivist paradigm accepting the ontological and epistemological contradictions.

The operational outcome of the study defined accordingly with the verified hypotheses, which were mainly contributed to enhanced behavioral and emotional human experience, evidence-based knowledge for urban design strategies and factual findings for the legislators and the regulators of the design disciplines

In conclusion, the knowledge acquired by applying the neuroscience approach in architecture was characterized by complexity and interconnectivity. The neuroscience approach in architecture has excellent potential to create alternative knowledge claims considering ontological and epistemological interpretations. The study field is mainly based on the interactions between the environmental features and the body-brain systems establishing multidisciplinary research. Additionally, beyond using multiple sources of evidence, the neuroscience approach in architecture uses the human being as the primary source of evidence that opens the infinite research probabilities while maintaining the ontological ties. Therefore, alternative knowledge claims must be developed to create architectural knowledge through those relations. As inferred from the literature and established through this dissertation, multidisciplinary perspectives are the only possible way of creating architectural knowledge concerning the human experience.

6. CONCLUSIONS AND RECOMMANDATIONS

Exploring the relationship between architecture and neuroscience, this thesis acquired and built research-based knowledge on; 1) the theory, methodology, and practice of the neuroscience approach in architecture and 2) the neuroscience of human experience, eventually setting out an architectural research framework for the neuroscience of human experience.

While this thesis disseminates new knowledge and provides a research framework for the neuroscience of human experience, it encourages future studies. The exponential growth of the study field continues. The theoretical framework of the thesis is based on the investigation of the neuroscience approach in architecture and the neuroscience of human experience, which is the study of the individuals' brains experiencing an architectural space, built and natural environments. The human brain is a complex phenomenon that is difficult to understand and explain. The more we deepen our knowledge of the human brain, the closer we may be to understanding human experience in the built environment. Experiencing architecture and the built environment is being under attack by numerous stimuli, including colors, shapes, textures, geometry, topography, light, sound, smell, taste, and the organization and the use of space that continuously creates behavioral, sensational, cognitive and emotional responses by affecting the body-brain systems of people. Moreover, the relationship between neuroscience and architecture can potentially enlighten the hardest issues of both disciplines which are empathy, embodiment, imagination, atmosphere, aesthetic judgment, and memory structures, including narrative and script writing which occur in an abstract manner. The future of the study field is promising to enhance the human experience within a holistic approach considering all the aspects of human nature.

Furthermore, the neuroscience approach in architecture is a broader term including 1) the investigation of designers' brains which could improve the studies on creativity and design thinking, and 2) the investigations on the buildings and cities' brains refer to a wide range of study field from social, cultural, environmental sustainability and smart cities to global issues as global warming, post-pandemic urbanism which can be studied as dynamic networks and adaptive living organisms.

Methodologically, applying improved methodological approaches by combining more devices for more accuracy, using the procedure for a more diverse population and places, studying multi-variables of architectural space by avoiding oversimplification, and creating a more holistic perspective on architectural issues might further the existing studies.

Practically, the research and design collaboration is still in its infancy. Advancing scientific evidence for design processes can promote tailored and qualified architectural and environmental features. To do so, the study field needs more research-based knowledge to apply to design processes. Although the study field mainly belongs to the positivist paradigm and is based on objective methods and findings, considering the practical implications and operational approaches, it works with endless dynamism. The scientific outcome of the study, which is the evidence, is unique, but the application of the evidence has excellent potential. The research-based knowledge enables the architecture professions to work with new perspectives opening new horizons in the field.

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