FULYA TOLUNAY

THE NEUROLOGICAL AND PYSCHOLOGICAL EFFECTS OF HUMAN AND NATURE INTERACTION:
WALKING IN NATURAL LANDSCAPES AND LANDSCAPED GARDEN ENVIRONMENTS

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THE NEUROLOGICAL AND PSYCHOLOGICAL EFFECTS OF HUMAN AND NATURE INTERACTION: WALKING IN NATURAL LANDSCAPE AND LANDSCAPED GARDEN ENVIRONMENTS

A Master’s Thesis

by

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Ankara

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To my mother,

Güneş

THE NEUROLOGICAL AND PSYCHOLOGICAL EFFECTS OF HUMAN AND NATURE INTERACTION: WALKING IN NATURAL LANDSCAPE AND LANDSCAPED GARDEN ENVIRONMENTS

The Graduate School of Economics and Social Sciences of
İhsan Doğramacı Bilkent University

by

FULYA TOLUNAY

In Partial Fulfillment of the Requirements for the Degree of
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İHSAN DOĞRAMACI BİLKENT UNIVERSITY
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By Fulya Tolunay

I certify that I have read this thesis and have found that it is fully adequate, in scope and quality, as a thesis for the degree of Master of Fine Arts in Interior Architecture and Environmental Design.

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ABSTRACT

THE NEUROLOGICAL AND PSYCHOLOGICAL EFFECTS OF
HUMAN AND NATURE INTERACTION: WALKING IN
NATURAL LANDSCAPES AND LANDSCAPED GARDEN ENVIRONMENTS

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Living in an urban environment causes a low connection with nature. Both Natural Landscapes (NL) and Landscaped Gardens (LG) have positive influences on human neurological and psychological well-being. The inter-discipline of neuroarchitecture provides for examining the neurological effects of the environment. This thesis aims to understand the difference between walking in NL (woodland with natural water features- Eymir Lake) and LG (human-made garden with artificial water features- Park Oran Residential Area) environments. The neurological methodology of the study has an electroencephalogram (EEG), a measurement to analyze before- after the alpha to the beta brain frequency band. The findings demonstrate that walking in LG has more potential to increase relaxation and decrease stress than in the NL environment. This study aims to contribute to a greater understanding of the correlation between the neurological and psychological effects of different types of natural environments.

Keywords: Neuroarchitecture, Alpha-Beta Brain Frequency Band, Electroencephalogram (EEG), Landscaped Garden (LG), Natural Landscape (NL),

ÖZET

İNSAN VE DOĞA ETKİLEŞİMİNİN NÖROLOJİK VE PSIKOLOJİK ETKİLERİ: DOĞAL PEYZAJ ORTAMLARINDA VE PEYZAJLI BAHÇE ORTAMLARINDA YÜRÜMEK

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Eylül 2022

Kentsel yaşamlar, doğa ile kurulan bağlantının zayıflamasına neden olur. Hem Doğal Peyzaj alanları hem de Peyzajlı Bahçeler, insanın nörolojik ve psikolojik sağlığı üzerinde olumlu etkilere sahiptir. Nöromimari, çevrenin insanın nörolojisi üzerindeki etkilerini inceleyen disiplinlerarası bir alandır. Bu çalışma, doğal su elemanı olan ormanlık alan (Eymir Gölü) ve yapay su alanı olan peyzaj bahçe ortamları (Park Oran Site Alanı) arasındaki nörolojik ve psikolojik farkları anlamayı amaçlamaktadır. Çalışmanın nörolojik metodolojisi, yürüyüş öncesinde ve sonrasında, alfa ve beta beyin frekans bandını analiz etmek için Elektroensefalografi (EEG) ölçümüne sahiptir. Çalışmanın sonuçları, peyzajlı bahçe alanlarında yürümenin rahatlamayı arttırma ve stresi azaltma potansiyelinin doğal peyzaj alanlarınndan daha fazla sahip olduğunu göstermektedir. Bu çalışma, farklı doğal ortam türlerinin nörolojik ve psikolojik etkileri arasındaki ilişkinin anlaşılmasına katkıda bulunmayı amaçlamaktadır.

Anahtar Kelimeler: Nöromimari, Alfa-Beta Beyin Frekans Bandı, Elektroensefalografi (EEG), Peyzajlı Bahçe Alanları, Doğal Peyzaj Alanları

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LIST OF ABBREVIATIONS

AIA	American Institute of Architects
ANFA	Academy of Neuroscience for Architecture
ART	Attention Restoration Theory
CNS	Connectedness To Nature Scale
ECG	Electrocardiogram
EDF	European Data Format
EEG	Electroencephalography
EEM	Emotional Engagement Measurement
ERP	Event-Related Potential
FFT	Fast Fourier Transform
fMRI	Functional Magnetic Resonance Imaging
GPS	Global Positioning System
HRV	Heart Rate Variability
ICA	Independent Component Analysis
LG	Landscaped Garden
MEG	Magnetoencephalography
METU	Middle East Technical University
NHAPS	The National Human Activity Pattern Survey
NL	Natural Landscape
PDS	Power Spectrum Density
PET	Positron Emission Tomography
POMS	Profile of Mood State
PSD	Power Spectral Density
SC	Spectral Centroid
DE	Spectral Energy
SPL	Superior Parietal Lobule

SRT	Stress Recovery Theory
SWB	Subjective Wellbeing
TMD	Total mood disturbance
VR	Virtual Reality

CHAPTER 1

INTRODUCTION

1.1. Problem Statement

Many cultures have been exposed to modernization, development, and ecological degradation, which are definitively associated with increased feelings of isolation and depression in modern urban environments (Mayer, 2004). Compared to their parent's generation, most people today have considerably fewer opportunities to interact with nature in daily life (Bratman, Hamilton & Daily, 2012). In 2001, The National Human Activity Pattern Survey (NHAPS) showed that people spend nearly 90% of their time indoors (Klepeis et al. 2001). Furthermore, urban environments have 75% of the population, increasing gradually (Vlahov, Galea & Freudenberg, 2005). According to Sampson, the disconnected humans from nature are the Third Crisis, the first and second global crises being climate change and loss of habitat and species (Sampson, 2013).

Urban environments provide ease of transportation, high-quality shelters, required energy, and better social interactions that are essential for feeling secure and part of a community. On the other hand, the system of urban environments causes a variety of negative impacts, including many negative physical health problems such as high blood pressure (Shanahan et al., 2016), obesity risk (Cotie et al., 2018), and psychological health problems including increasing stress (Berto, 2014), anxiety (Bratman, Daily, Levy & Gross, 2015) and depression (Peen, Schoevers, Beekman & Dekker, 2010). A new field of neuro urbanism addresses these issues, applying neuroscience laboratory methods to tackle global urban problems and promote the health of city dwellers (Pykett, Osborne & Resch, 2020).

Aspinall et al. (2015) were interested in the relationship between the environment, behavior patterns, and emotions. They implemented mobile Electroencephalography (EEG) data collection while walking through three urban environments: an urban shopping street, a green space, and a busy commercial district, for approximately 25 minutes. The results showed that walking in the green garden increased the meditation level. On the other hand, an experiment by Zhang (2019) and his colleagues compared the effects of natural landscape versus landscaped garden photographs using Functional Magnetic Resonance Imaging (fMRI), which is quite similar to this study.

Even though there is a substantial part of research on urban life, natural and landscaped environments, and their effects on human psychological and physical health, they do not focus on water features. Furthermore, a few studies investigating the influence of water features do not use functional imaging measurements. This researcher is hoping to fill this gap in the literature. The importance of this research is that using the functional brain imaging measurement to collect scientific objective data to compare natural and landscaped gardens with water features will achieve a novel scientific insight into natural areas within urban environments and their effects.

1.2. Aim of the Study

The study aims to analyze the neurological and emotional differences between natural landscapes and landscaped gardens with water features. This study achieves this aim by collecting neurological data before and after walking in different environments and implementing a questionnaire for both settings in order to compare the results.

1.2. Structure of the Thesis

The following sections describe key components of the research to achieve its aim and objectives. Chapter 2 presents the relative literature review on the effects of 'nature experience' in urban environments and water features. It discusses the psychophysiological effects of nature experiences in urban areas, especially human and nature intentional interaction: walking. The final part of Chapter 2 introduces the term neuroarchitecture with its history, definition, and methodologies comparing similar studies. The methodology of the study is explained in Chapter 3. It presents the research questions and the hypotheses. Then, it describes the sample and elaborates on the design of the experiment, including sampling, setting, procedure, and data analysis focusing on objective data collection (EEG Raw Data, Performance Metrics) and subjective data collection (POMS and CNS written surveys). Chapter 4 presents the results of the experimental data and discusses the findings from the perspective of the previous studies. Chapter 5 is the conclusion, where the study summarizes the implications of the major findings along with the limitations of the study and recommendations for further research.

CHAPTER 2

LITERATURE REVIEW

2.1. Nature Experience in Urban Environments

70% of the worldwide population lives in urban environments, and most of them lack a connection with nature. Furthermore, statistical estimation for 2050 is that two-thirds of the global population will live in urban areas (Vlahov et al., 2005). Landscaped gardens in urban environments positively affect ecosystem services, improve city dwellers' lives, and decrease health problems (Lederbogen et al., 2011). Trees in urban areas, for instance, may reduce air pollution by absorbing certain air contaminants from the atmosphere (Nowak, Crane, & Stevens, 2006). Environmental quality includes a variety of vegetation, and easy public transportation while minimizing the sound and air pollution of traffic, facilities, and services (Dahmann, Wolch, Joassart-Marcelli, Reynolds, & Jerret, 2010). Longer than 15 min in high-quality natural environments promotes the feeling of vitality significantly (Tyrväinen, 2014).

The increased number of landscaped gardens in urban areas provides better psychological, physical, and mental health (Gascon, Zijlema, Vert, White & Nieuwenhuijsen, 2017). For instance, research in Finland investigated the effects of sitting and walking in three different urban areas; a city center, a park, and an urban woodland on psychological (restorativeness, creativity, and mood) and physiological (salivary cortisol concentration) well-being. The experiment separates green environments as urban parks and urban woodlands and concludes that there is a relatively slight difference in the effects measured. However, prolonged sitting in the urban woodland may have a higher restorative effect than sitting in the urban park. On the other hand, the most significant difference between urban woodland and the city center is in a positive mood and restoration. Additionally, participants have higher creativity in green environments (Tyrväinen et al., 2014).

MacKerron and Mourato's (2013) experiment has an innovative data collection design which has a smartphone app for randomly getting signals from participants' location from Global Positioning System (GPS) and giving a brief questionnaire about Subjective Wellbeing (SWB). They collected over one million responses from more than 20,000 participants. The results show that participants feel happier in greenery outdoor environments (MacKerron & Mourato, 2013).

Ronghua (2019) and colleagues researched the effects of characteristics of urban green spaces on both aesthetic preference and perceived restorativeness with 24 photomontage images by manipulating four dimensions: the number of trees, flowers, water features, and animals like birds and fish, relative to a baseline photograph taken in China. The experiment results show that the restorative potential increases with the number of trees, flowers, and water features but is not affected by animals. For this reason, there was a strong positive correlation between aesthetic preference and restorativeness. Furthermore, the research pointed out that urban landscaped design archives greater restoration with high aesthetic quality with water features and an increased number of trees and flowers (Ronghua, Zhao, Meitner, Hu & Xu, 2019).

Alvarsson, et. al.’s (2010) experiment compared visual relations with the natural and urban environments with their auditory stimulation with regard to psychological stress recovery by using an Electrocardiogram (ECG) to collect Heart Rate Variability (HRV). The experiment results show that the natural environment with the sound of nature has more sympathetic activation for increasing relaxation and stress recovery (Alvarsson, Wiens & Nilsson & 2010).

2.2. The Psychological and Psychophysiological Effects of Nature Experience

During the daytime, the physical, psychological, and social resources have reduced if not meet the demand for refreshment and relaxation. The term restoration means recovery and healing effects of these sources (Amicone & Petruccelli, 2018). The literature has two main theories about the restoration effects of nature on human psychology. The first theory is the Stress Recovery Theory (SRT) by Ulrich, which explains that interaction with nature increases positive emotions and decreases stress (Ulrich et al., 1991). Another theory is Kaplan’s Attention Restoration Theory (ART), which explains the restorative effects of nature on attention (Kaplan et al., 1989).

The SRT emphasizes that natural environments may influence recovery from physiological stress and refresh the emotional state (Ulrich & Addoms, 1981). The physiological findings suggested that the parasympathetic nervous system is strongly influenced by responses to nature (Ulrich et al., 1991). Ulrich's (1981) experiment combined EEG and physiological sensors to demonstrate that urban environments stimulate the brain more than greenery settings (Ulrich, 1981). According to the study's findings, natural environments reduce levels of negative emotions such as fear and moderate physiological arousal (Ulrich et al., 1991).

ART can provide an accurate theoretical description of how nature might restore and improve cognition and attention in individuals (Kaplan, 1995). However, the theory focused on the notion of fascination for the process of attention restoration. According to ART, restoration from directed attention fatigue occurs with psychological effects such as; being away, fascination, extent, and compatibility. Moreover, nature's soft fascinating characteristics can lead to a recovery of directed attention. Kaplan and Kaplan's (1989) study shows that natural environments provide these four factors more than urban environments. In addition, the possibility of engaging natural environments to provoke bottom-up involuntary attention is responsible for this effect (Joye & Dewitte, 2018). Because urban environments often contain distracting stimuli, including overpopulation, unwanted sounds, and, poor air quality (Berman, Jonides & Kaplan, 2008), directed attention may need to involve even more effort for stimulation, potentially exacerbating directed attention fatigue. Restorative nature experiences are thus assumed to be recovery effects in the most common theoretical characterization of ART: nature facilitates the replenishment of an initially depleted resource that is directed attention. Stephen Kaplan claims that nature should feel more relaxed and familiar because our ancestors evolved in a natural setting. The critical point is that ART can provide a theoretical analysis explanation of how nature can benefit from attention restoration and improve cognitive performance capacity (Kaplan, 1995).

The main difference between these theories is that SRT emphasizes the role of nature in relieving physiological stress, whereas ART emphasizes the role of nature in relieving mental fatigue (Frumkin et al., 2017). Although both theories have similarities, using the ART framework is more often concerned with how natural environments can replenish depleted cognitive resources. In contrast, research using the SRT framework is more concerned with how natural environments can help people recover emotionally and physiologically from the stresses and strains of everyday life, particularly in urban areas (White, Pahl, Ashbullby, Herbert & Depledge, 2013).

Whether the two theories address complementary processes may depend on the relative timing of environmental effects and the given measurements. For example, different impacts of interaction with natural environments can appear in approximately 4 minutes in physiology (Ulrich et al., 1991) and emotional states in approximately 10–15 minutes (Ulrich, 1979). On the other hand, intentional interactions like walking in nature have not consistently emerged after 15 minutes (Hartig, Evans, Jamner, Davis & Gärling, 2003), but they have appeared after more prolonged periods.

2.3. Water Element in Nature Experience

The essential value of water has been known since ancient societies (Solomon et al., 2010) and was called a 'sacred substance' in history (Strang, 2020). Moreover, most spiritual rituals include water for healing and refreshing power. For this reason, the priority of water in landscapes is an indispensable part of establishing and sustaining the existence of living organisms (Herzog and Barnes, 1999). Moreover, historical research shows that most urban environments are located on riversides to promote human health and achieve sustainable accommodation needs (Strauss, Lepoutre & Wood, 2017).

The presence of water in urban environments positively contributes to environmental, psychological, physiological, social, aesthetic (Karmanov and Hamel, 2008), and economic (White,2010) conditions. For instance, natural settings with water features have lower environmental stressors such as air pollutants and noise (Markevych et al., 2017). On the other hand, psychological studies show that water features reduce psycho-physiological stress (Ulrich & Addoms, 1981), replenish attentional capacities (Kaplan, Kaplan & Brown, 1989), and, enhance wellbeing (V¨olker & Kistemann, 2011) by increasing restoration. Nutsford (2016) and associates conducted experiments in Wellington, New Zealand, to measure psychological distress using the Psychological Distress Scale for adults. The results show that higher psychological well-being is related to a water view from home. Additionally, natural environments with water features provide a qualified chance for physical activities (Pasanen, White, Wheeler, Garrett & Elliott, 2019), gathering, and socializing with multi activities with family and friends, improving social cohesion and interaction (Markevych et al., 2017).

Furthermore, the visual, auditory, and physical relationships can increase the effect of the water. For example, an auditory relationship with the water is the most unique sound of nature with a remarkable restoring and calming effect (Burmil, Daniel & Hetherington, 1999). Moreover, a visual relationship with water in addition to an auditory relationship will increase the visual rating of the scenery (Smith, Croker & McFarlane, 1995) and fascination (Laumann, Gärling & Stormark, 2001). Regan and Horn (2005) found that water features utilize restoration and recreational leisure activities with an increasing happy mood state. Figure 1. demonstrates the main contribution and related categories of water features in urban environments.

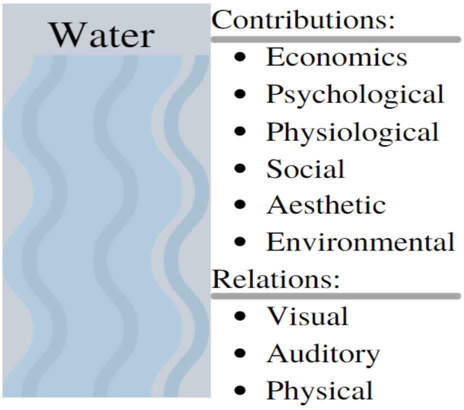


Figure 1. Categories of water features

Reviewing the literature showed that water feature experience has been categorized under the following points: kinetic recreational experience, situation-based recreational experience, harvest experience, and substitution or aesthetic experience. Table 1. shows the four types of water feature experiences (Van der Smissen & Christiansen 1976). This research mostly focused on aesthetic experiences such as watching the natural and artificial lakes.

Table 1. Water-recreation experience was studied by Van der Smissen and Christiansen (1976)

Types	Description	Activities
Kinetic Recreational Experiences	The high degree of motion in water (mechanically powered and non-mechanically)	-Boating, -Sailing -Canoeing -At the water's edge like cycling or jogging (Yamashita, 2002)
Situation-based Recreational Experiences	Exact location with several times experience	-Walking -Swimming, - Ice skating, -Scuba diving, -Social interactions (Smith et al., 1995)
Harvest Experiences	Concerned with harvest (Consumptive. product-oriented),	-Fishing -Harvesting, gathering, or collecting
Substitution or Aesthetic Experiences	The passive exploration of water features (views and sounds)	-Bird -Watching, -Game spotting, -Drawing and painting, -Taking photography

White (2010) and colleagues studied water features' effects and perceived restorativeness as well as the preferences of the participants. Their experiment has 120 photographs which are classified according to the ratio of "aquatic"/"green"/"built" (rivers, lakes, coasts). First, the results show that the most restorative environment is aquatic-green. Secondly, aquatic-only and green-aquatic environments are equally distributed. The last built-only environments are the least restorative. shows the results of restorativeness of all types of environments that are seen in Figure 2.

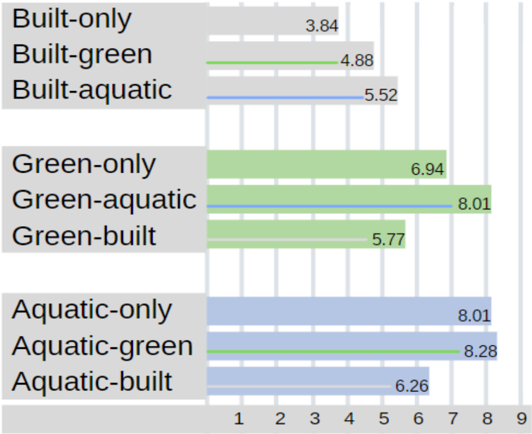


Figure 2. White et al. (2010) water-recreation experiences

A subsequent study by White (2013) and colleagues studied the effects of different natural environments on restoration (calm, relaxed, revitalized, and refreshed). They collected data from 4255 participants. The results show that visiting landscapes with water features is more restorative than visiting urban environments. Finally, an experiment by White (2017) investigated the relationship between natural environments and SWB with the classification of three types of exposure (neighborhood exposure, visit frequency, and specific visit). A regular visit to natural environments gives eudaimonic well-being and a feeling of worth in their lives. The findings are significant for policies to protect and promote public access to qualified natural areas with water features.

According to urban and landscape designers, creating water features are more complicated than green areas because of maintenance, financing, and construction time (Luttik, 2000). The study classifies the three essential natural components as water, vegetation, and diversity in order to enhance societies' ecological, natural, and cultural characteristics (Asakawa, Yoshida, and Yabe, 2004). For this reason, in urban environments experiencing high-quality natural environments, which means containing water features, is essential for public health to promote physical activities such as walking (Gidlow et al., 2016). Furthermore, the presence of water in the landscape positively contributes to human beings and environmental sustainability. For this reason, policymakers should allocate private financing or joint public-private financing for water features in greenery areas (Völker & Kistemann, 2011).

2.4. Human and Nature Interaction: Walking

The literature has three main types of interaction with nature: indirect, incidental, and intentional, categorization can be seen in Table 2. The indirect interactions do not require being physically present in nature, like viewing an image or motion picture of nature. Incidental interaction, on the other hand, means experiencing nature as a by-product of another activity like walking to work or driving in natural environments. The final type of intentional interaction specifies being in nature through direct interaction like gardening or camping (Keniger, Gaston, Irvine & Fuller, 2013). The interaction categorization is an essential distinction because it appears that only a narrow percentage of a population will interact with nature on purpose. However, the intent to interact may be pivotal in promoting sustainable behaviors in society (Buttazzoni, Veenhof & Minaker, 2020).

Table 2. Types of interactions between people and nature by Keniger and Gaston (2013)

Interaction Types	Description	Examples
Indirect	Experiencing nature while not being physically present there.	View nature in a picture, image, motion picture, or window.
Incidental	Experiencing nature as a A by-product of another activity.	Walking to work or driving, encountering vegetation indoors.
Intentional	Experiencing or being in nature through direct intention.	Hiking, camping, wildlife the viewing, adventure gardening, or farming.

Walking in natural environments has significantly more restorative (Berman et al., 2008; Hartig et al., 2003), and meditative effects (Sugiyama, Leslie, Giles-Corti & Owen, 2008) than in urban environments. Gidlow's (2016) and colleagues' experiment compared psychological and physiological responses to a 30-minutes walk in three different environments: residential, natural, and natural with water. The experiment measured mood, cognitive function, restoration experiences, salivary cortisol, and HRV. The results show that natural and artificial water have better restoration effects. Studies comparing urban and natural environments give similar results. The positive psychological effect increases as the perceived biodiversity in natural landscapes increases (Fuller, Irvine, Devine-Wright, Warren, & Gaston, 2007). In natural areas, we have more chances to experience biodiversity, but also there are different types of the natural environment. Recent research shows that the water and mountain landscapes have the best attention restoration abilities among urban and forest landscapes (Tang et al., 2017). Walking in nature contributes to health simply by energy expenditure regardless of the purpose of walking (transport or recreation). For health benefits, periods of at least 10 minutes of walking have an essential role in physical health. Walking for more prolonged periods has also been found to have some health benefits over walking in short periods (Barton, Hine & Pretty, 2009).

Hartig et al. (1991) did not find significant differences in blood pressure or heart rate measured after a 40-min walk in a natural or urban field setting. However, their study results show that walking in a natural environment has a more significant positive effect on the emotional state than walking in an urban environment. Harting (2003) and colleagues studied the comparison of stress recovery and directed attention restoration in natural and urban settings using repeated measures of ambulatory blood pressure, emotional self-reports, and attention collected from 112 randomly assigned young adults. The experiment's procedure was to sit in a room with or without views of trees and then walk in a nature reserve or a medium-density urban area. The results demonstrate that the end of the walk-in natural setting increased positive emotions and decreased anger more than the urban environment.

Johansson and others' (2011) study compares the urban outdoor environments (park and street) and immediate social context (with or without a friend). Furthermore, each walking environment has different according to water features, greenery diversity, closeness to traffic, and the human population. The results demonstrate that some of the psychological benefits of taking a brisk walk are shaped by the immediate social context and features of the outdoor urban environment, including natural features (Johansson, Hartig &Staats, 2011).

A lack of physical activity plays an essential role in physical and mental health. However, most people in urban areas do not have easy access to natural environments for physical activities in their daily routines. For this reason, physical activity such as walking for recreation and transportation is discouraged in some urban outdoor environments (Frumkin, Frank, & Jackson, 2004). Therefore, identifying the characteristics of urban environments according to discourage or promote walking may increase accessibility, sustainability, and quality of the physical activities in urban environments.

2.5. Neuro-architecture

2.5.1. History and definition of neuro-architecture

The first document about the nervous system in the seventeenth-century b.c was written by Imhotep, an Egyptian royal physician, and architect of the pyramid in Sakkara. On the other hand, the brain may not have been regarded as a vital organ at the period, frequently not preserved in burial procedures. After over a thousand years, Greek philosophers tried to understand the anatomical location of the mind. Plato (427–347 b.c.) assumed that the brain functioned as a mental process, and Hippocrates (460–379 b.c.) conjectured that the brain was a controller of sensation and intelligence (Edelstein,2016). Classical philosophy and psychology-initiated questions about mental function, constitute the discipline of cognitive neuroscience.

The branch of Neuroscience means the scientific study of the nervous system including the brain, peripheral nervous system, and spinal cord, researching their functions. The rapid growth of functional brain imaging methods provides a scientific understanding of open questions related to social sciences. Meanwhile, neuroscientific research has begun to collaborate between various disciplines (Papale, Chiesi, Rampinini, Pietrini & Ricciardi, 2016). Today, neuroscience has continuously developed with a wide range of computational approaches and technologies of sub-disciplines and methodologies in both scientific studies and clinical practice. Therefore, the human brain is considered one of the most complex living structures ever discovered. According to recent studies, the human brain contains 200 billion neurons, producing tens of thousands of connections (Micheva, Busse, Weiler, O'Rourke & Smith, 2010). Before the 1980s, the brain was considered to be fixed or unmodifiable. However, significant quantities of studies demonstrated that the brain grows new cells (neurogenesis) and makes new connections with change and adaptation (neuroplasticity) (Fuchs & Flügge, 2014). These neuroplastic changes may be influenced by various factors such as stress and aging, conscious attention, repetition, and reward (Biederman & Vessel, 2006). The essential point is that environmental quality and repeated activities have the power to change and enhance the connection of signal transmission (Koehl & Abrous, 2011). These findings encouraged The American Institute of Architects (AIA) to collaborate with neuroscientists to investigate how improvements to the built environment may alter the brain's perception. In the 25-year award ceremony, Louis Kahn's design at the Salk Institute of Biological Sciences, Dr. Jonas Salk drew designers' attention to research "the power of architecture" on the relation between the internal mind and external surroundings (Papale et al., 2016). Afterward, the Academy of Neuroscience for Architecture (ANFA) was founded in 2003 to encourage scientists, architects, and designers to research how neuroscience knowledge can redefine design. ANFA is a non-profit organization that aims to increase knowledge by integrating neuroscience research to develop human responses to the physical environment (Rad et al., 2021).

The new discipline of neuroarchitecture answers how the environment affects the brain and its processes. Architectural research has traditionally been based on philosophical theories or behavioral patterns related to human responses. In contrast, these methods provide descriptive data that cannot identify the causes of specific behaviors in built environments. Recent neuroscientific research has attempted to fill the gap between architecture and psychology by explaining how different environments affect neurological causes to behavioral results (Vartanian et al., 2013). Neuroscientific study shows how certain physical characteristics influence sensory, perceptual, kinetic, emotional, cognitive, or behavioral functioning. Furthermore, studies show that exposure to the environment can create an experience that alters the brain (Edelstein, 2016).

Another new field is neuro urbanism, related to psychophysiological and neurological research on the relationship between urban stress, density, city landscapes, architectural forms, well-being, and the human brain (Pykett et al., 2020). Therefore, brain-based landscape design focuses on how the physical environment affects neural processes of memory, mental state, learning, sensation, perception, emotions, behaviors, and decision-making longer-term effects of urban living are considered a risk factor for mental health in neuro urbanist planning (Adli et al., 2017). Neurourbanism and neuroarchitecture are interdisciplinary practices that collaborate neuroscience, architecture, planning, public health, architecture, and other design fields (Al-Barrak, Kanjo & Younis, 2017).

2.5.2. Neurological methods for understanding architecture

Scientists consider the human brain one of the most sophisticated living organisms ever discovered. In recent years, technological developments in neurology have provided new methods for easy-to-use data collection to influence different architectural styles on humans' perception, behavior, emotion, and cognition (Edelstein, 2016). Developed neuroimaging methods are divided into two categories which are structural and functional methods. Structural imaging refers to specialized systems for the visualization and analysis of anatomical properties of the brain.

On the other hand, functional imaging distinguishes brain areas and underlying brain processes involved in performing a specific cognitive or behavioral task (Hirsch, Bauer & Merabet, 2015). Table 3. **s**hows a brief explanation of functional imaging measurements. The most preferred neuroimaging methods in neuroarchitecture include EEG (measuring the electrical activity of the brain), Positron Emission Tomography (PET) (to use magnetic fields and radio waves), Functional Magnetic Resonance Imaging (fMRI) (detecting an increase in blood oxygen in brain areas), Magnetoencephalography (MEG) (measuring the magnetic field produced by electrical activity). Each neuroimaging technique collects different outputs to identify neural networks, illustrating the merits and demerits of cost, safety, and the temporal and spatial resolution of using each method (Keshavarz, Campos & Berti, 2015). Only a few studies preferred to use multiple neurological measurements. For instance, Shemesh et al.'s (2015) study has three scientific devices, including wireless EEG, wireless Eye tracker, and

Emotional Engagement Measurement (EEM) systems, to investigate differences in the perception of spatial spaces between professional groups versus non-professionals. According to findings, the professional group was more interested in curvy rooms and felt familiar with the area. However, significantly, the field of interior design researchers used 77.8 % of the EEG and only % of the 22.3 fMRI, probably because of the movement and budget limitation of fMRI.

Table 3. A brief explanation of functional imaging measurements

Name	Description	Purpose
EEG	-Measuring the electrical activity of the brain -Measuring event-related activities -Focusing on band frequency and ERP	-To show changes in brain activities -Recording brain wave patterns with peaks and drops over a period of time
PET	-Uses magnetic fields and radio waves -Measuring density and location of brain	-To provide detailed pictures of brain structure
FMRI	-Detecting an increase in blood oxygen in brain areas	-To examine the anatomy of the brain structure
MEG	-Measuring the magnetic field produced by electrical activity -Mapping brain activity by measuring the magnetic field	-The shielded room is necessary -Determining the function of various brain areas and neurofeedback

EEG is a non-invasive method of determining the electrical activity generated by brain regions on the surface of the cortex (Teplan, 2012). The EEG method utilizes to measure spontaneous & event-related activities in the brain. It focuses on band frequency to show changes in brain activities by recording brain wave patterns with peaks and drops over time (Rad, 2021). For instance, Nguyen and Zeng's (2014) study examines mental stress by measuring EEG signals when performing design tasks. The study results show that when one has the highest stress level causes the lowest cognitive function that affects using the potential of creativity. Moreover, new portable EEG devices provide innovative experiment designs combined with Virtual Reality (VR). Another study's methodology combines VR, EEG, and Event-Related Potential

(ERP) to present objective neurophysiological results about the difference between the effects of sustainable and conventional buildings on human cognitive abilities (Hu, Simon, Fix, Vivino & Bernat, 2021).

The method of fMRI is an alternative neuroimaging method that shows hemodynamic changes in the brain according to increased blood flow (Logothetis, Pauls, Augath, Trinath, & Oeltermann, 2001). The growth of fMRI has allowed research in various fields of science (Papale et al., 2016). For this reason, the study creatively redefines the boundaries of environmental research and uses technology to understand human and nature relations for increasing connection. For example, using fMRI, Pati et al. (2016) studied the effects of the curve and sharp contours on amygdala activation and behavioral response habits in interior health care settings. Another experiment using the fMRI established the role of the amygdala and hippocampus in processing fear (Zelikowsky, Hersman, Chawla, Barnes, & Fanselow, 2014), sadness (Phan, Wager, Taylor, & Liberzon, 2002), and task difficulty (Churchill et al., 2016). The neuroarchitectural researchers focus on environmental qualities that support psychophysiological conditions, including cognitive functions (Gegenfurtner, Kok, Van Geel, De Bruin & Sorger, 2017), emotion states, sensation, and perception (Edelstein,2016) more than programmed space (residential or non-residential).

2.5.3. The benefits and potential of neuroarchitecture

Interdisciplinary research means achieving an integrative and interactive approach to analysis, synthesis, and harmonizing diverse disciplines to a new level of knowledge and perspectives about research (Choi & Pak, 2007). Besides environmental psychology, human factors, and ergonomics, neuroarchitecture includes research related to the function of the brain and mind with neurological, sociological, psychological, and physical responses (Edelstein, 2006). A combination of architecture and neuroscience disciplines can explain what might be 'better' or 'worse' in terms of design for humans due to key lessons in biology, cognitive science, and psychology (Hollander & Foster, 2016). In this context, neuroarchitectural principles provide a broader understanding of the diversity of human and environmental relations to contribute to urban design and interior design, facade design, natural scene, energy and building, and formal and spatial organization (Rad, 2021).

The literature has not had enough studies that provide objective evidence proving the effects of built environments with real environment stimulation. However, neuroarchitectural experiments can be conducted on different stimuli such as laboratories, using images, VR, real environment experience, and walking through paths. The innovative methodologies of neuroarchitecture can alter lab-oriented experiments to realistic and multi-dimensional environments to understand human and environment relationships with objective data collection (Rad,2021). This understanding of the relationship between the environment and human activities has a safeguarding and promoting role in health and may affect the design solutions of architects, urban planners, and interior designers.

Recent studies show that the quality of built environments has a direct and measurable effect on health and well-being from micro to macro levels, such as individuals, societies, economies, and ecologies (Edelstein, 2016). Furthermore, the causes of changes in the human brain and mind experience of architectural settings link cognitive neuroscience to architecture (De Paiva and Jedon, 2019). In addition, design features reflect the principles of evolutionary psychology that influence and produce predictable brain wave responses.

Moreover, Norwood et al.'s (2019) systematic review of neuroarchitecture research results indicated that the field's methodology and thematic base have expanded for explaining different types of environments on brain activities and emotional responses. Finally, Ghamari et al. 's (2012) systematic review summarize the most current brain imaging techniques and methodologies according to interior design, urban design, and building design. The results indicate that in recent years, fMRI and EEG have been used more than other techniques, mainly in neuroarchitectural research involving human emotion, feeling, and perception (Ghamari, Golshany, Rad & Behzadi, 2021). Among the neuroarchitecture experiments, the most neuroimaging technique is the EEG because of the high temporal resolution of electrophysiological signals with an efficient recording program (Rad, 2021). On the other hand, measuring brain activity is an objective method of identifying the neurological impact of a relationship with the environment (Keshavarz et al., 2015). For this reason, the field of neuroarchitecture has an essential role to fill the gap by exploring neurophysiological reactions to environmental experiences (Banaei, Hatami, Yazdanfar & Gramann, 2017).

2.5.4. Studies about neuro-architecture and nature

The knowledge of humans and nature has been examined over the years, but new technologies provide better and more neurological scientific results. For this reason, neuroarchitecture, being an interdisciplinary field, contribute to designers' and architects' understanding of the complicated association between the brain and environment (Homolja, Maghool & Schnabel, 2020). The multi-faceted characteristics of neuroarchitecture may diversify to acknowledge with collaboration a significant amount of other fields (Ghamari et al., 2021).

The literature has an enormous number of studies comparing urban and rural environments which show the negative effects of urban environments on human health (Peen et al., 2010; Menardo, Brondino, Hall, Pasini, 2021). Lately, Roe et al. (2013) study used the portable EEG device (Emotiv EPOC) to compare the effects of the urban and natural environments on mental health. The results show that living in high greenery areas is associated with lower stress levels. Another research compared the restorative value of four types of natural landscapes (urban, mountain, forest, and water) and analyzed the relationship between the different environments and brain region activity by using fMRI. The results show that the water and mountain environments have higher restoration than forest and urban (Tang et al., 2017). Moreover, Zhang et al. (2019) study used the fMRI method while showing photographs of natural landscapes and landscape gardens and performed scene-type judgment tasks. The appreciation of landscaped gardens and natural landscapes is based on the same neural pathways. However, the contrast between landscape gardens and natural landscapes was characterized by stronger activations in the occipital lobe and the left Superior Parietal Lobule (SPL) related to attention and visuospatial perception. A wider perspective is that not only the protection of natural landscapes but also the understanding of designing efficient and effective landscape gardens are critical for city dwellers' health.

On the other hand, most of the population lives in urban settings. There are different types of environments within the urban setting that have different effects on human health. For example, Aspinall et al. (2013) used a mobile EEG device (Emotiv EPOC) to record and analyze the emotional experience when participants conducted a 25-minute walk through three areas (urban shopping street, green space, and busy commercial district) of Edinburgh, Scotland. The study results show a multi-dimensional relationship between green space and emotional change. For example, when participants walk into a green space from a high-density area, they experience positive emotions like less frustration, increased engagement, increased interest (arousal), and calmness. Likewise, Al-barrak et al.'s (2017) experiment has portable EEG (NeuroSky) with real-time environmental monitoring sensors to collect environmental variables like the noise of spaces and air quality. While data is being collected, the participants walked through different places (the cafe, the supermarket, and the garden). The results demonstrated that the highest meditation level and lowest brain fatigue are seen in the garden with higher alpha activity. In addition, a higher beta activity related to mental activities was observed in supermarkets. Besides comparing different types of environments, examining the environmental quality, like having the green feature, provides better results towards an understanding of the health benefits of natural environments. For example, greenery in shopping areas has stress-reducing and restorative effects along with health benefits were proven by analyzing the data coming from a mobile EEG device (Emotiv EPOC) (Rosenbaum, Ramírez & Matos, 2019).

CHAPTER 3

METHODOLOGY

3.1. Research Questions and Hypotheses

This study analyzes the neurological and emotional effects of walking in natural landscapes and landscaped gardens with water features. The study answers the following research questions:

RQ1: Are there any significant neurological differences between natural landscapes and landscaped gardens in terms of brainwaves (beta and alpha frequency in the frontal lobe)?

RQ2: Are there any significant emotional differences in the restorative effect of walking in natural landscapes and landscaped gardens?

RQ3: Are there any significant psychophysiological differences in the restorative effect of walking in natural landscapes and landscaped gardens in terms of stress and relaxation level?

This experiment has the following hypothesis:

H1: The high Beta brainwave frequency in the frontal lobe, which is related to the high-stress level, slows down from Alpha frequency after walking near the water feature in both natural landscapes and landscaped gardens.

H2: Walking near the water features in landscaped gardens has a more significant restorative effect on the emotional state than in natural landscapes.

H3: Walking in landscaped gardens significantly differs in stress-relaxation levels from walking in natural landscapes.

3.2. Participants

This experiment has 54 participants (25 female, 29 male). The age range of the participants was between 18 and 30 years old (Mean: 23,93 SD: 2,487). The participants were randomly divided into two groups (each group had 27 participants) which can be seen in Figure 3. The experiment had a snowball sampling method for reaching more participants. Furthermore, the main criteria for the participants were not having any diagnosed with any mental, neurological, or psychological disorders. Additionally, the participant should not consume food for 2 hours and caffeine for 3 hours before the experiment to minimize autonomic regulation. The experiment was approved by the Ethics Committee of Bilkent University (NO: 2022_01_18_02). To eliminate of participant's stress about the experiment, the researcher started the experiment with a brief explanation of the experiment and the Emotiv Insight device. Then, the participants signed a consent form that includes a brief of the experiment and the precautions to avoid any risks. In the beginning, the total participant number was 78 but 24 of them were excluded due to the low contact quality (under 64 %) problem.

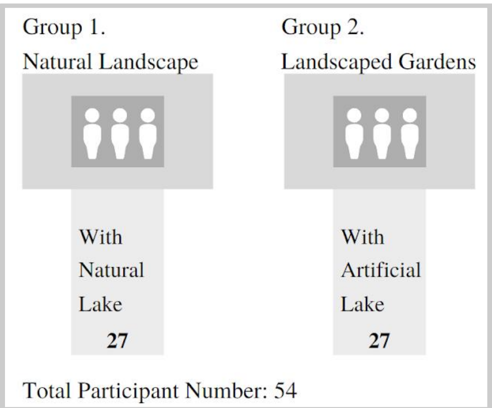


Figure 3. The experiment sampling

3.2. Settings of the Experiment

In the study, there were two types of settings categorized as the natural landscape and landscaped garden. The closeness of their locations can be seen in Figure 4. The experiment was conducted in the Middle East Technical University (METU) forest area near Eymir Lake, referred to as the natural landscape setting with natural water features and natural paths and trees. The Park Oran residential area is referred to as the landscaped garden with 12 high-rise Residences (32 floors) and five low-rise Residences (6 floors) with artificial water features various types of plants and trees. Figure 4. shows the walking paths in both settings.

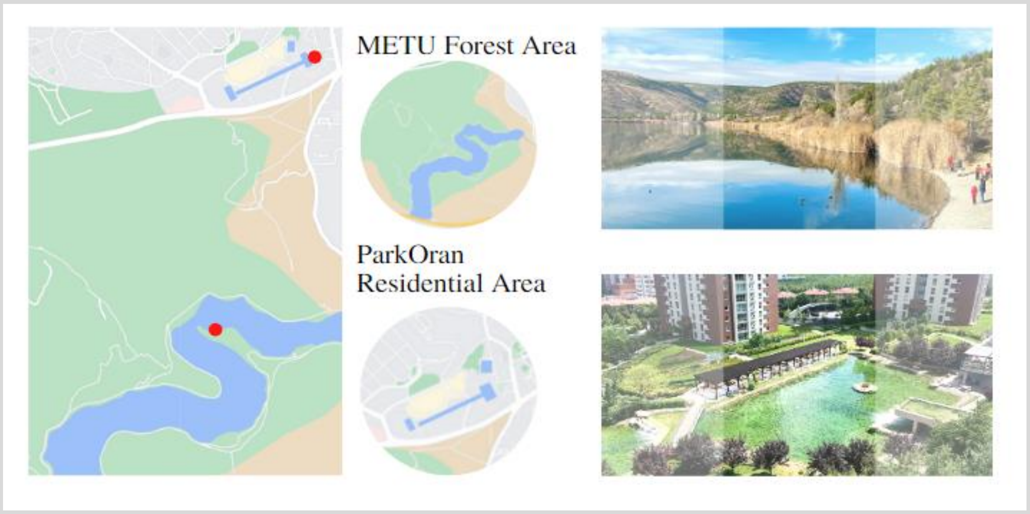


Figure 4. The Google Maps View of Settings

Li and colleagues (2020) experiment artificially controlled the physical environment by creating a semi-circular dome-shaped cabin with a radius of 2.4 m to equate the level of temperature, humidity, and carbon dioxide (Li, Jin, Lu, Wu & Wang, 2020). However, real-environment experiments have limited environmental control. According to Johansson (2011), the environment experience is affected by traffic and other people's noise. However, in the real environment experiments create stimulation of that areas without perfect silence and private area. Bratman (2015), physical environments may be investigated under five categories which are geographic, infrastructure, biological differences, audio, and climate. In terms of categories, this study examines these in 3 types which are equal, variables, and characteristics of the setting. Table 4. shows the categorization of both settings according to similarities and differences. Type daylight with the level of sunshine and circadian rhythms (Beute & de Kort, 2014) influences psychological restoration. For this fact, the schedule of the experiment was arranged at the same time of the day. During the period for data collection, the weather conditions differences according to the average temperature between -3 and +7 degrees Celsius may not be significant (Johansson et al., 2011). Furthermore, the experiment's timeline eliminated the climate differences by being conducted in the same season (Felsten, 2009) and in geographically (Keniger et al., 2013) close locations. On the other side, both geographic and infrastructure characteristics do not need to control to obtain variability of settings. For instance, road network and building density are higher in landscaped garden settings than in natural landscaped ones. On the other side, biological differences like the level of diversity of plants are higher in the landscaped garden.

Table 4. The experiment setting comparison

		Natural Landscape	Landscaped Garden
Geographic	Topography	Variable	
	Proximity to Water	Equal	
Build Infrastructure	Road Network	Lower	Higher
	Building Density	Variable	
Biological	Diversity	Variable	
Audio	Degree of Traffic/ Human Noise	Lower	Higher
	Degree in Natural Sound	Higher	Lower
Climate	Thermal Comfort	Equal	
	Weather	Equal	
	Season	Equal	
	Time of Day	Equal	

3.3. Instruments

The study had two types of instruments; the questionnaires and the mobile EEG instrument. The conducted questionnaires are as follows: Profile of Mood State (POMS) (McNair, Lorr & Droppleman, 1971), The Connectedness to Nature Scale (CNS) (Mayer & Frantz, 2004), and Self-reported Experience. In addition to questionnaires, the experiment had a neuroimaging measurement instrument called Emotiv Insight as a mobile EGG. Before walking, the procedure started with filling out both POMS and CNS surveys, then collecting EEG data via Emotiv Insight. After walking, the procedure continued with collecting EEG data to obtain in neurological effects of walking in nature. Finally, the participant filled out both POMS and Self-report experience.

3.3.1. Profile of Mood States Questionnaire (POMS)

The general mood and psychological well-being can alter a temporary negative and positive state of mind or feeling. For example, the perceived environment (Berto, 2014), behavior patterns, and physical health (Cohen & Rodriguez, 1995) can impact mood positively or negatively (Berger & Motl, 2000). The original version of the POMS was created in 1971 by McNair, Lorr, and Droppleman (1971) and consisted of 65 items; an abbreviated 30-item version of the POMS has been developed more recently (McNair et al., 1971). The POMS was designed to evaluate affective traits, emotion, and mood with related descriptive words/statements to determine participants' feelings using a 5-point Likert scale (0 for 'not at all and 4 for 'extremely'). The main mood categorization includes Tension (T), Anxiety (A), Fatigue (F), Vigor (V), Confusion (C), and Depression (D) are the five dimensions of the scale (Appendix C). Total mood disturbance (TMD) was calculated by subtracting the vigor score from the sum of all the other mood scale scores. The TMD is a clinically relevant and highly reliable measure of overall mood and mood problems, with higher scores indicating more significant mood disturbance. A higher TMD score indicates a higher negative mood (Barton et al., 2009);

$$TMD = T + A + F + C + D - V$$

POMS questionnaire is preferred to evaluate mood changes in various settings, especially the relationship between mood and exercise (Baker, Denniston, Zabora, Polland & Dudley, 2002). In addition, the International Society of Sport Psychology (1991) explains that exercise is related to desirable changes in mood, and the POMS has been a widely used measurement of the relationship between mood and physical activity. In this study, the short version of POMS was used to collect data about the participants's before and after walking moods (Gidlow et al. 2016).

3.3.2. The Connectedness to Nature Scale (CNS)

The CNS is a reliable and valid scale to measure individuals' attribute levels of emotional connectedness with nature (Mayer & Frantz, 2004). The CNS has functional psychometric properties corresponding to related variables (e.g., the new environmental paradigm scale, environmentalist identity), unrelated to potential confounds (Mayer & Frantz, 2004). The CNS should predict ecological behavior better because it can measure the 'wellness' that individuals experience in their relationship with nature. The resulting scale consisted of 14 items designed to measure how participants generally feel a part of the natural world. Participants responded on a 5-point Likert scale (1 for 'strongly disagree' and 5 for 'strongly agree', see Appendix B).

3.3.3. Self-reported Experience

The self-reported experience was composed of demographic questions and experience questions, which were categorized under the nature experience (questions 1-2-3-4), self-reported stress level in the last month (question 5), and the experience of the experiment (questions 6-7-8-9). The first part has four questions about participants' connection with nature in their daily life routine. The responses to these questions are significant for analyzing the setting distributions and correlation with CNS. Stress has three measurement categories: neurophysiological, emotional changes, and self-report (Berto, 2014). Question 5 aims to analyze participants' stress range as a self-report with a 4-point Likert scale (1-Never, 2-Sometimes, 3-Often, 4-Always) (Valdez et al., 2020). According to Evans (1987), stress means individually the biological, psychological, and social relation of person-environment transactions and differs from person to person. In the experiment, some components like weather, wearing the emotive device, and walking may affect participant stress levels. For this reason, the last four questions determine the presence of any discomforting conditions for the participants during the experiment (Appendix D).

3.3.4. Emotiv Insight

Emotiv is a bioinformatics company advancing the understanding of the human brain using EEG. The company presents mobile and easy-to-use devices for collecting raw EEG data and performance metrics, one of the latest technological devices. The wireless connection and 20 hours of battery life features provide ease to conduct outdoor experiments. The general look and the use of the Emotiv Insight device can be seen in Figure 6.

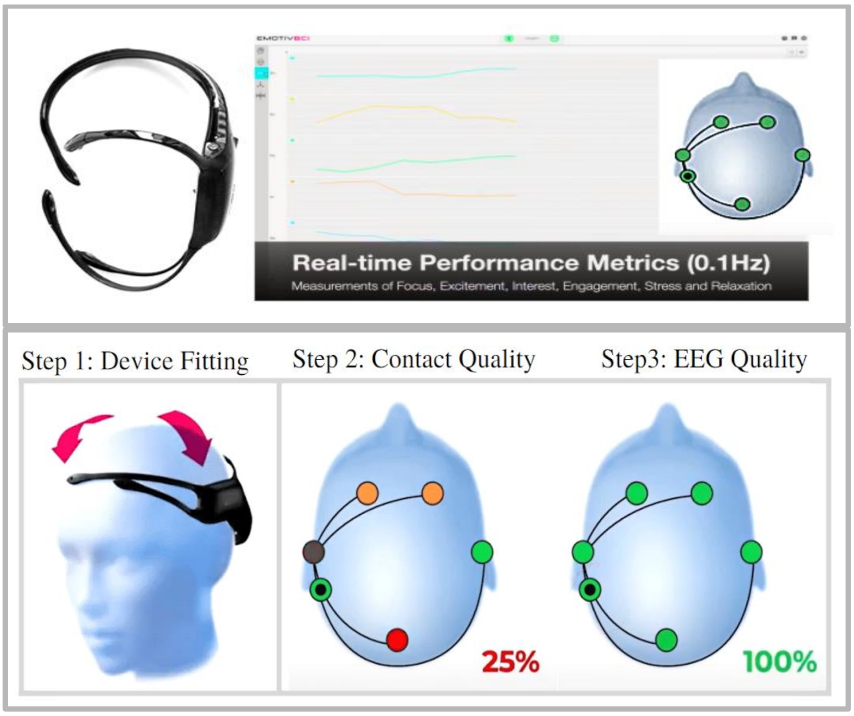
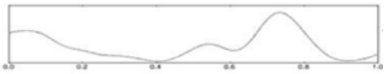
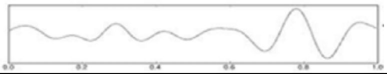
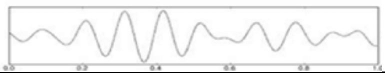
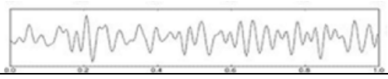


Figure 6. The Emotiv insight, (emotiv.com)

In the experiment; the Emotiv Insight device collected both Raw EEG data and performance metrics which included 6 emotion states: stress, relaxation, interest, focus, excitement, and engagement. The Emotiv Insight device has a five-channel (AF3, T7, Pz, T8, and AF4), semi-dry polymer sensor that is easy to use and collects data from all cortical lobes of the brain. This thesis only analyzed the relaxation and stress performance metrics in AF3 and AF4 with alpha to high beta frequency. The frequency response is 0.5-45 Hz, which is categorized by Delta (0.5-4), Theta (4-8 Hz), Alpha (8-12 Hz), Low Beta (12-16 Hz), High Beta (16-25 Hz), Gamma (25-45 Hz). The nature of the brain is electrochemical (Dispenza, 2013). When nerve cells are activated, charged elements are exchanged, resulting in electromagnetic fields. The EEG is the most preferred measurement of the brain's various electrical activities. Furthermore, human brain development has a sequence of brain-wave alterations as children grow, the frequencies that predominate in their brains progress from Delta (0-2 age range) to Theta (2-5 age range) to

Alpha (5-8 age range) and then to Beta (above 8-12) (Dispenza, 2013). The gate between the conscious and subconscious minds closes typically after twelve. Table 5 shows the main classifications of frequency bands (cycles per second=hertz (Hz)).

Table 5. Typology of brain frequencies

Frequency Band	Frequency	State
Delta (δ)	0.5–4 Hz 	The lowest levels of activity, deep sleep
Theta (θ)	4–8 Hz 	The subconscious mind (half-awake and half-asleep)
Alpha (α)	8–12 Hz 	The creative, imaginative state
Beta (β)	12–35 Hz 	Conscious thought, external attention

Beta waves are classified into low, mid, and high. As children grow older, they tend to move from low-range Beta waves to mid-and high-range Beta waves. Low-range Beta, ranging from 13 to 15 hertz, is seen in states of relaxed, interested attention and paying a certain level of attention without being particularly vigilant. Mid-range Beta, ranging from 16 and 22 hertz, defines our conscious or rational thinking and alertness. High-range Beta has a pattern from 22 to 50 hertz, represents over-stressful thinking like a high-arousal state, and negatively causes a decrease in effective learning, creativity, and problem-solving because of high levels of anxiety, worries, anger, pain, suffering, frustration, and fear (Dispenza, 2013). When the brain perceives less information from the environment, such as intentionally closing eyes and purposefully going inward, Beta frequency slows down to Alpha. Additionally, the main functions of the frontal lobe are concentration, observation, awareness, and consciousness. The more relaxed consideration automatically activates the frontal lobe which means alleviating synaptic firing in the neocortex (Dispenzia, 2013).

However, dramatic physiological changes can be seen in the heart, lungs, and sympathetic nervous system arousal, and psychological changes may be seen in behaviors, emotions, and perception. According to Dispenzia (2013), the high beta band represents a short-term survival mechanism (fight-or-flight response). However, most of the adult population has a high beta in the long term, which causes stress and imbalance in the mind and emotions. For this reason, a great number of people suffer from anxiety disorders, depression, obsessive-compulsive disorder (OCD), insomnia, and chronic fatigue syndromes.

3.4. Procedure

This study was designed as a systematic assembly of four subsequent phases. Phase I (definition of Landscaped Garden (LG) and Natural Landscape (NL) with water features), phase II (selection of LG and NL environments with walking paths and neurological measurement of EEG device), phase III (conducting the experiment), phase IV (analyzing the data from the experiment).

The first phase included research on differences between LG and NL with regard to the effects of water features on humans and nature connection. In the research, intentional interaction (walking) was accepted as a connection. Before achieving interdisciplinary insight into neuroarchitecture, the researcher first investigated the psychophysiological effects of nature experience on humans. The term Neuro-architecture was explained with regard to its history, benefits, potential, methods, and experiments. The second phase had three main stages: selection of experiment settings, selection of a measurement device (Emotiv Insight for collecting EEG raw data), and selection of written surveys (POMS and CNS). The third phase of the study was composed of two stages: preparing a real environment setting for walking and collecting data (EEG, POMS, and CNS). The final phase of the study was analyzing the data for final results. First, Emotiv Insight EEG data were analyzed with MATLAB+EEGLAB then results were calculated with SPSS. Figure 7. shows the procedure of this thesis.

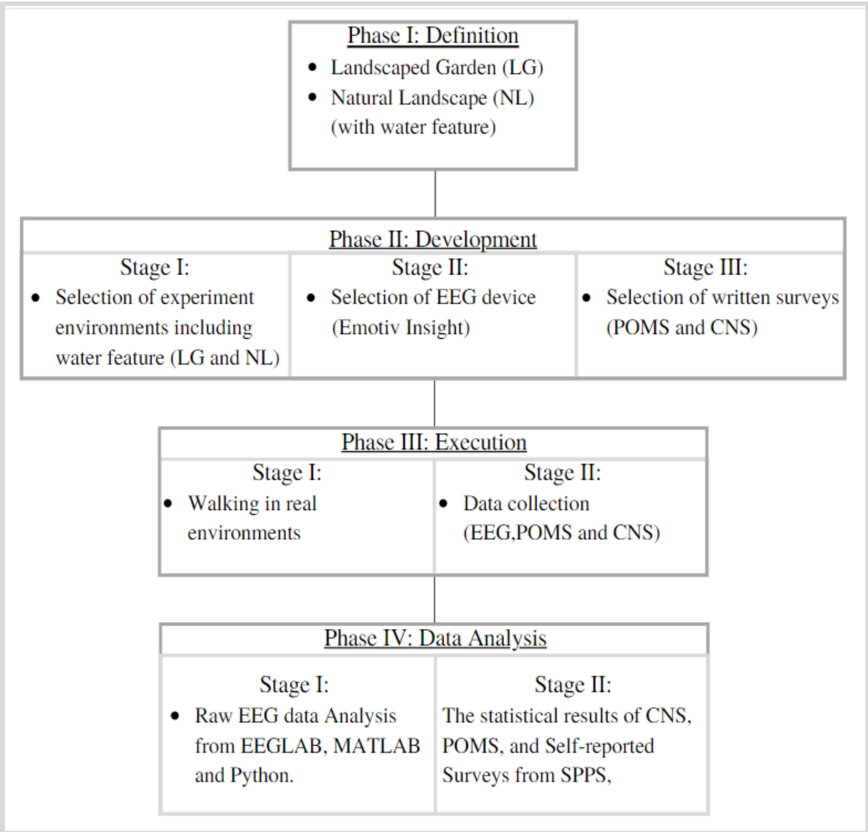


Figure 7. Procedure map of the study

The experiment was conducted in April 2022. During the experiment periods, the average temperature was 26 Celsius. For temperature difference, all experiments started at 1 pm. and finished at 5 pm. The experiment procedure started with giving brief information about the general experiment procedure. After, participants were asked to start filling in the questionnaires of both POMS and CNS. While the researcher prepared the EmotivPRO program and Emotiv Insight Device. After the survey, the researcher helped the participants to wear the EEG device by adjusting the location of the sensors to achieve a better connection. During the adjustments, the connection quality was checked on the Emotiv Pro application (above 98% of sensor connection quality) of the Emotiv Insight device. Then, collected EEG data for 1 minute. Afterward, each participant walked individually for approximately 20 minutes on a walking path near the lake. Both setting lakeside walking routes determined approximately 1.5 kilometers, an average of 20 minutes of walking. The map view and walking view of settings can be seen in Figure 8. After finishing walking, the collection of EEG raw data was repeated, and later the participant took POMS and Self-reported Experience. The total duration of the experiment for each participant was approximately 40-45 minutes. Additionally, each time the Emotiv Insight device was disinfected by the researcher.

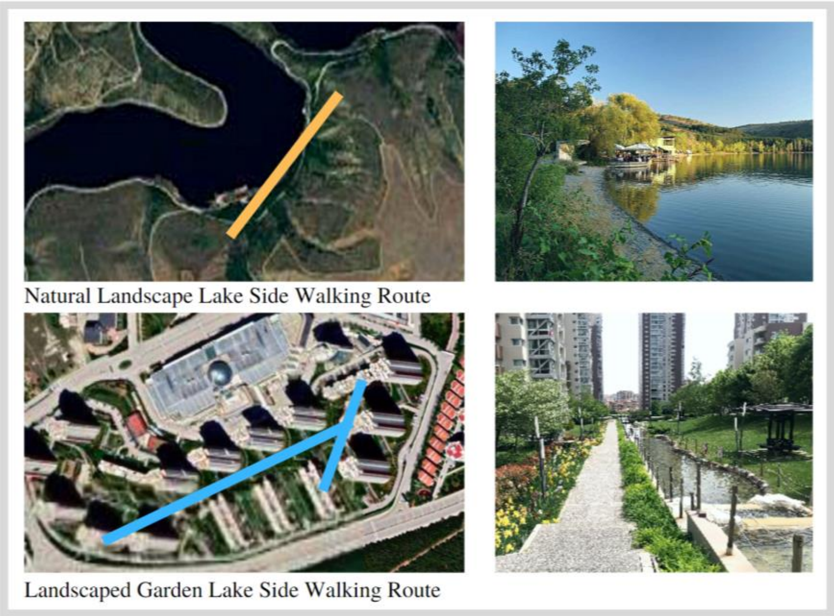


Figure 8. The walking paths of the experiment

3.5. Data Analysis

3.5.1. Emotive PRO

EMOTIV Pro is a detailed software available to use for neuroscientific research and educational purposes. The toolkit allows the user to build & publish their experiments, by collecting high-quality EEG Data. The program can give different types of output data: raw EEG, Motion data, Contact Quality, EEG Quality, or Performance metrics. The general program qualifications can be seen in Figure 8. Before collecting data, Emotiv Launcher provides a connection to the device (Emotiv Insight). The toolkit of Emotiv Pro records participants' data and then allows the user to view the real-time data streams that include raw EEG, performance metrics, and motion data. The storage of data streams allows the user to switch between data streams while allowing them to review the data in real-time. The recorded data can be stored locally or on the EMOTIV Cloud. Furthermore, to measure cognitive states and behaviors in real-time, EMOTIV's machine learning algorithm distills brain activity patterns and turns the data into psychological and mental performance indicators.

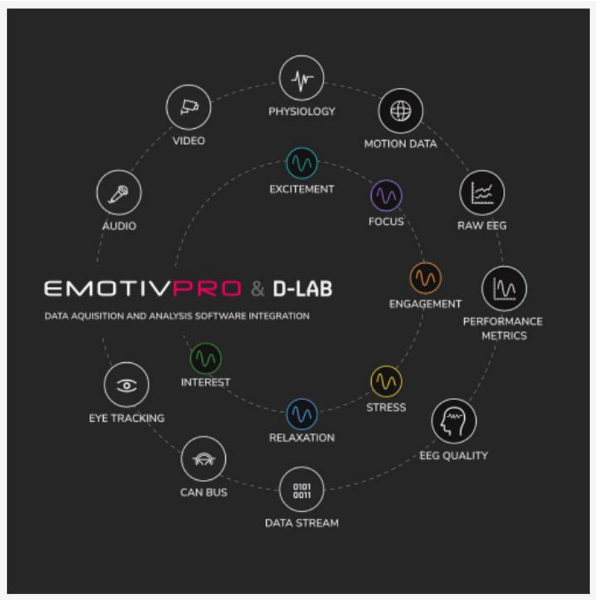


Figure 8. Emotiv PRO program qualifications

3.5.2. Raw EEG Data Analysis

Raw EEG data analyses were conducted using the EEGLAB v2022.0 running in Matlab R2021a (The Math-Works, Natick, MA, USA). The program has multiple options and layers for the practical needs of users. For instance, the function of the top layer provides users to analyze data through the graphic interface without needing to use MATLAB syntax. Furthermore, the middle-layer functions provide customizing data processing that increases the flexibility and adaptability to research (Delorme & Makeig, 2004). Analyzing Raw EEG data with EEGLAB has four main steps: import data, preprocess data, reject artifacts, and plot data can be seen in Figure 9. From the EEGLAB plugin layer, European Data Format (EDF) file was imported including EEG data with channels, an columns. After importing data, the program requires the user to fill in the channel list. The calculation of channels and columns gave the channel list number (5:9). Then, for the 'Edit → Channel locations' function, the insightCED.ced. file (Heunis, 2016) was used.

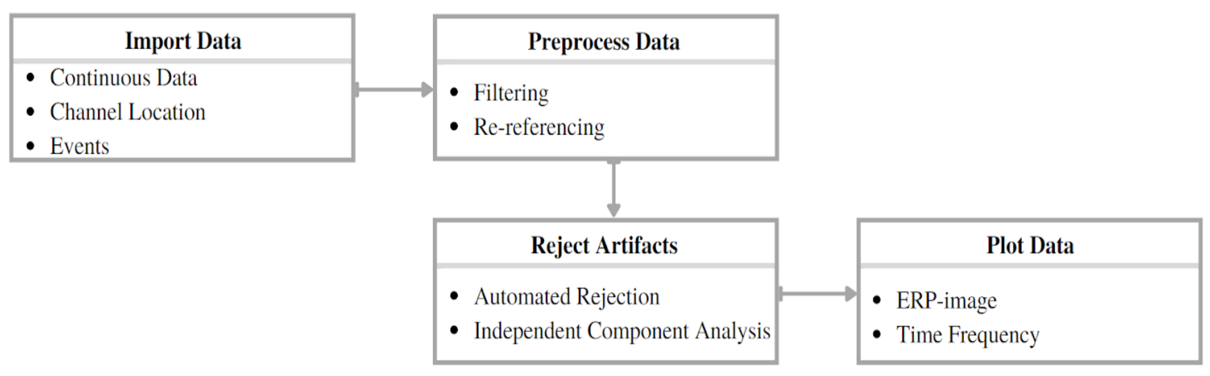


Figure 9. Procedure map of the EEG data analysis

The second step of preprocessing data started with filtering data. The main aim of filtering continuous data is to reduce artifacts at epoch boundaries. In this research for analyzing alpha and beta band ranges, the lower edge of the frequency pass band was adjusted to 5 Hz and the higher edge of the frequency pass band to 32 Hz. The following step of rejecting artifacts started with running an Independent Component Analysis (ICA) (Makeig & Jung, 2000). This blind automatic process filters the algorithms that include overlapping, strong, independent components such as eye-movement activity, single peaks in the scalp waveforms, and steady-state responses (Pantev et al., 1993) regardless of their spatial distributions (Makeig & Jung, 2000). For statistical analyses, the data was exported by Export File → 'data and ICA activity to text files' including table time, channels, and brain wave numerical changes. Each data was preprocessed individually by filtering the effects of noise and artifacts for the accurate transformation of numerical data. This numerical voltage recording includes a table of milliseconds and Hertz (Ms/Hz).

The following step was Time-frequency analysis, simultaneous signal to process on frequency and time resolution with different frequencies (Gu & Bollen, 2000). In the literature, Time-frequency analysis has many conceptually and mathematically different methods for analyzing frequency bands (Roach & Mathalon, 2008). In this study, data were analyzed with the Fast Fourier Transform (FFT) method, utilized for statistical data analysis of EEG signals. The advantage of FFT is suitable analysis with framed narrowband signal (Al-Fahoum & Al-Fraihat, 2014).

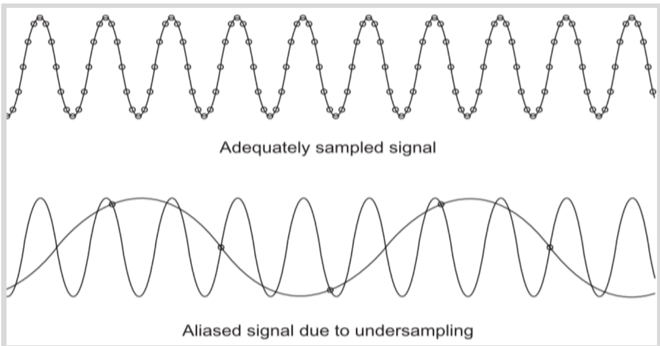


Figure 10. Adequate and Inadequate Signal Sampling by Cerna & Harvey (2000)

FFT framed signal contains three statistical features; Power Spectrum Density (PDS), Spectral Energy (SE), and Spectral Centroid (SC). Power Spectral Density (PSD) means spectral power per unit of frequency (power/frequency = W/Hz) that provides frequency content signals. The main function of the SC is obtaining the dominant spectral energy from the power spectrum (Murugappan, Murugappan, Balaganapathy & Gerard, 2014). In this analysis, the FFT wave band is framed with spectral features from alpha wave (8Hz – 13 Hz), low beta (13 - 20 Hz), and high beta (22-35 Hz). The collected EEG signals in Emotiv Pro were recorded as the sampling frequency was 64 Hz. According to Nyquist–Shannon sampling theorem (reproduce a pure sine wave measurement) the x-axis was determined to be half of the sampling frequency (32) (Khudiakov, 2008; Cerna & Harvey, 2000), can seen in Figure 10. After a one-sided FFT conversion, the x-axis represented the frequency and the y-axis represented the signal magnitude.

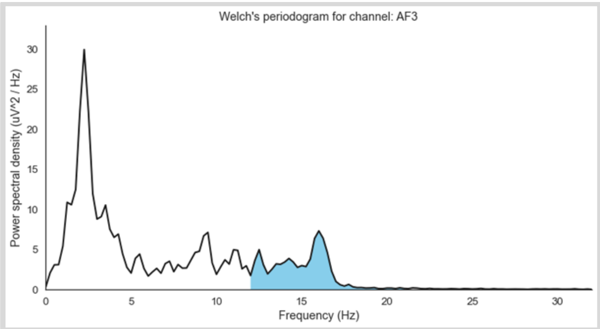


Figure 11.The FFT analysis in Python

Welch's periodogram approach was used to convert the signal to the frequency axis for spectral density estimation. Then, the numerical value (Absolute Power) of the blue parts is seen in Figure 11. was calculated using Simpson's rule, divided areas into several parabolas as micro-Volts-squared per Hz (uV2 / Hz). The ranges of Hz were filtered for all cases separately and calculated as a single numerical value. After EEGLAB, all steps were completed in Python 3.0 using the Pandas, Numpy, and Scipy library (source codes: signal.py).

3.5.3. Statistical Analyses

The collected data were processed and analyzed using Statistical Package for Social Sciences (SPSS) software version 19 software, which stands for Statistical Package for Social Sciences. For statistical analysis, all quantitative data were listed using the SPSS software. Firstly, a descriptive analysis was conducted to examine the demographic characteristics of the participants. Furthermore, reliability analysis tests were completed to determine the consistency of the questionnaire items. Secondly, frequency analysis for mean and Standard deviation scores was calculated. In addition, crosstabulation analysis was examined for correlation between variables and results. Finally, Independent Samples t-tests were conducted to analyze both emotional and neurological effects of walking in NL and LG.

CHAPTER 4

RESULTS

4.1. Descriptive statistics

The aim of descriptive statistics is a numerical and graphical description of data variables (Fisher & Marshall, 2009). This section provides a general summary of the emotional, neurological and, psychological differences between walking in NL and LG. Firstly, the demographic data of the participants were analyzed. According to the results, the experiment has 25 female and 29 male participants. Table 6. shows the gender distribution of the participants for both experiment settings. The average age of the participants was 23.29 years (SD= 2.487). Secondly, mean scores were calculated for Independent Samples t-tests to obtain the difference between before and after walking for both experiment settings. Finally, cross-tabulation (correlation) analyses were conducted to find the relationship between the results.

Table 6. Distribution of gender

		Natural Environment		
		Natural Landscape	Landscaped Garden	Total
Gender	Female	12	13	25
	Male	15	14	29
Total		27	27	54

4.2. CNS Results

Before analyzing the neurological and emotional effects of walking in NL and LG, it was essential to identify participant connectedness with nature. Among the participants, the lowest score was 2.86, and the highest was 4.71. The calculated mean score of CNS is 3.7306 (SD: 0.33213). According to the statistical analysis, 66% of the participants gave an average score of connection with nature (see Table 7).

Table 7. Results of the mean scores for CNS

		Natural Environment		
		Natural Landscape	Landscaped Garden	Total
CNS	to low	0	1	1
	low	6	2	8
	medium	17	19	38
	high	3	4	7
	to high	1	1	2
Total		27	27	54

4.3. Self-reported Experience Results

4.3.1. Experience of Nature

Besides CNS analysis, the self-reported nature experience is essential for identifying participants' perceptions about the visual and physical relationship to nature. Overall, 79% of the participants reported that they have a greenery area close to where they spend most of the time (Q1). However, 64% of participants had a visual connection to that greenery area (Q2). Moreover, 61% of the participants had the habit of walking in that area (Q3) (see Table 8). On the other hand, regardless of the close location of the greenery area, the mean score of weekly spending time in nature (Q4) is 2.30 hours (SD: 0.903) (see Table 9). Only 12% of participants reported that over 6 hours a week spent their time in nature.

Table 8. Crosstab results of the experience of nature (Q1-2-3)

		Natural Environment		
		Natural Landscape	Landscaped Garden	Total
Q1: Is there a green area close to the building where you spend the most time during the day?	Yes	19	24	43
	No	8	3	11
Q2: If so, can you see that area from the window?	Yes	14	21	35
	No	13	6	19
Q3: Do you have a habit of walking in parks or natural green areas?	Yes	16	17	33
	No	10	10	20

Table 9. Crosstab results of the experience of nature (Q4)

		Natural Environment		
		Natural Landscape	Landscaped Garden	Total
Q4: How much time do you spend in nature per week?	0-60 mins	6	3	9
	1-3 hours	11	16	27
	3-5 hours	6	5	11
	over 6 hours	4	3	7
Total		27	27	54

4.3.2. Self-reported Stress Level

Besides the objective data of neurological changes, the self-reported stress level question examined the participants' stress level in their life at present for their perception. According to the 4-point Likert scale, the self-report mean score was 2,89 (SD: 0,789). 53% of the participants had answered sometimes. Additionally, the scales of 'Often' and 'Always' had the same results, 20% of the participants. Only 5% of the participants had no stress in that period of their life (see Table 10).

Table 10. Crosstab results of the experience of nature (Q5)

		Natural Environment		
		Natural Landscape	Landscaped Garden	Total
Q5: Please mark your stress level in your life at present on the following scale.	Never	0	3	3
	Often	5	6	11
	Sometimes	17	12	29
	Always	5	6	11
Total		27	27	54

4.3.3. Experience of Experiment

According to the results, non of the participant felt uncomfortable during the experiment (Q7). In cross tabulation distribution analyses, only 2 of the participants felt uncomfortable because of the weather condition during the experiment (Q8). Results regarding the self-reported feeling of the walking experience (Q9), 2 of the participants who walked in NL did not enjoy the walking experience. On the other side, the majority of participants (52) experienced a comfortable experiment experience (see Table 11).

Table 11. Crosstab results of the experience of the experiment (Q6-7-8)

		Natural Environment		
		Natural Landscape	Landscaped Garden	Total
Q7: Did you feel comfortable during the experiment?	Yes	27	27	54
	No	-	-	-
Q8: Did the weather disturb you during the experiment?	Yes	27	25	52
	No	-	2	2
Q9: Did you enjoy the walk during the experiment?	Yes	25	27	52
	No	2	0	2

4.4. POMS

Table 12. Results of the independent samples t-test for POMS

Experiment Setting	**Category**	**Time-Line**	**M**	**SD**	**t**	**df**	**Sig. (2-tailed)**
LG	Anxiety (A)	Before	16,52	11,109	1,879	52	,066
		After	11,04	10,316			
NL		Before	15,07	9,466	1,540	52	,130
		After	10,93	10,307			
LG	Tension (T)	Before	16,07	7,109	2,734	52	,009
		After	10,85	6,927			
NL		Before	14,30	6,420	2,504	52	,015
		After	9,81	6,726			
LG	Vigor (V)	Before	19,37	4,508	1,254	52	,215
		After	17,63	5,631			
NL		Before	19,85	5,763	,151	52	,881
		After	19,59	6,818			
LG	Fatigue (F)	Before	11,93	6,183	2,682	52	,010
		After	7,56	5,787			
NL		Before	11,63	5,160	1,589	52	,118
		After	9,00	6,878			

LG	Confusion (C)	Before	11,70	5,305	1,858	52	,069
		After	9,11	4,941			
NL		Before	12,63	5,583	2,216	52	,031
		After	9,41	5,093			
LG	Depression (D)	Before	14,78	12,876	1,328	52	,190
		After	10,26	12,110			
NL		Before	12,89	8,907	1,428	52	,159
		After	9,41	9,010			
LG	TMD	Before	51,67	37,009	2,000	52	,051
		After	31,63	36,603			
NL		Before	47,63	28,110	2,075	52	,043
		After	30,44	32,582			

The sub-scales results show that 'Tension' has a higher statistical difference between environments. In NL, before walking mean score was 14.30, and after walking mean score NL: 9.81 (p: 0.015). On the other side, in LG, before walking mean score was 16.07, and after walking mean score NL: 10,85 (p: 0.009). The POMS overall score TMD and six sub-scales were calculated with separation of before and after walking. An independent sample t-test was conducted to find the statistical relationship between them. The calculation of TMD and every six sub-scales can be seen in Table 12. TMD mean score in LG was before walking 51.67 (SD:37.009) and after walking 31.63 (SD: 36.603, p: 0.051). On the other side, NL before walking was 47.63 (SD:63) and after walking 30.44 (p: 0.043).

Table13. Comparison of Differences Sub-scales of POMS

Sub-scales of POMS	Subscale Differences	Factors Difference
Anxiety (A)	6,62	1,37
Tension (T)	9,71	0,73
Vigor (V)	1,43	0,91
Fatigue (F)	7	1,74
Confusion (C)	5,81	0,63
Depression (D)	8	1,04

Table 13. shows the comparison of both before-after sub-scale scores difference and experiment settings. Before and after mean scores of subscales' maximum difference can be seen in order of ‘Tension’ (9.71), ‘Anxiety’ (9.62), and ‘Depression’ (8). On the other side, the least difference was seen in ‘Vigor’ (1.43). The comparison of setting analysis demonstrated that in LG the lowest scores can be seen in ‘Fatigue’ (1.74) and ‘Anxiety’ (1.34). However, the sub-subscale of ‘Confusion’ (0,63) had the lowest score of difference. According to the results, the p-value of 'Tension' (p: 0.09) is above 5 % of significance. There are no significant results and the null hypothesis is confirmed.

4.5. Performance Metrics Results

Table 14. Results of the independent samples t-test for performance metrics

Factors	Conditions	M	SD	T	Df	Sig.
Natural Landscape Stress	Before	9,22	5,515	1,519	48,888	,135
	After	7,19	4,261			
Landscaped Garden Stress	Before	12,5	7,523	2,594	38,816	,012
	After	7,9	3,862			
Natural Landscape Relaxation	Before	11,93	6,810	,735	37,873	,465
	After	10,85	3,348			
Landscaped Garden Relaxation	Before	16,70	9,840	2,838	33,902	**,006**
	After	10,93	3,882			

In order to compare the participants' relaxation and stress, performance metrics levels exported Emotiv Pro with separation of minimum and maximum values. The categorization of min and max values was essential to obtain the difference between both before-after walking and settings. The independent samples t-test results showed that there was no significant difference between groups in terms of all subscales (see Table 14). The mean results were calculated for each participant individually using SPSS. The mean score range calculation showed that stress mean scores before walking was NL: 9.22 LG: 12.5 and relaxation mean scores before walking NL: 11.93 LG: 16.70. However, after walking stress mean scores were NL: 7.19 (p: 0.135) and LG: 7.9 (p: 0.012) and after walking relaxation mean scores were NL: 10.85 (p: 0.465) and LG:

10.93 (p: 0.006). According to the results, the main difference calculated in LG relaxation (p: 0.006) is above 1 % of significance. There are no significant results and the null hypothesis is confirmed.

Table 15. Results of the independent samples t-test for performance metrics range

Factors	Conditions	M	SD	T	Df	Sig.
Natural Landscape Stress Min. Value	Before	28,52	4,089	,506	51,966	,615
	After	27,96	3,985			
Landscaped Garden Stress Min. Value	Before	27,48	8,192	,106	37,368	,916
	After	27,30	3,930			
Natural Landscape Stress Max. Value	Before	37,30	7,119	1,223	48,711	,227
	After	35,19	5,456			
Landscaped Garden Stress Max. Value	Before	39,81	11,796	1,875	41,812	,068
	After	34,89	6,869			
Natural Landscape Relaxation Min. Value	Before	23,37	7,365	,232	47,762	,818
	After	22,96	5,417			
Landscaped Garden Relaxation Min. Value	Before	25,00	6,691	-,120	51,960	,905
	After	25,22	6,880			
Natural Landscape Relaxation Max. Value	Before	35,44	11,683	,510	39,336	,613
	After	34,15	6,138			
Landscaped Garden Relaxation Max. Value	Before	41,63	12,668	2,150	44,236	0,370
	After	35,41	8,106			

4.6. EEG Data Frequency Comparison Results

Table 16. The independent samples t-test for AF3-AF4 frequency band

Factors	Channels	Frequency Band	Conditions	M	SD	t	Df	Sig. (2-tailed)
Natural Landscape	AF3	Alpha (α)	Before	5.101	2.285	-0.406	52	0.686
			After	5.433	3.358			
		Low Beta (β)	Before	5.561	3.903	-1.475	52	0.146
			After	7.902	7.263			
		High Beta (β)	Before	0.237	0.106	-0.158	52	0.874
			After	0.232	0.116			
	AF4	Alpha (α)	Before	8.028	3.800	-0.723	52	0.472
			After	8.847	4.487			
		Low Beta (β)	Before	6.238	3.470	-1.695	52	0.095
			After	9.116	8.105			
		High Beta (β)	Before	0.246	0.146	0.0007	52	0.999
			After	0.245	0.130			
Landscaped Garden	AF3	Alpha (α)	Before	15.161	42.2	-0.059	52	0.952
			After	15.757	30.4			
		Low Beta (β)	Before	24.959	78.178	0.241	52	0.809
			After	21.155	23.969			
		High Beta (β)	Before	0.425	0.285	-0.985	52	0.329
			After	0.050	0.283			
	AF4	Alpha (α)	Before	18.45	40.949	0.048	52	0.967
			After	18.01	30.055			
		Low Beta (β)	Before	25.955	81.109	0.327	52	0.327
			After	20.617	24.492			
		High Beta (β)	Before	0.431	0.531	0.197	52	0.844
			After	0.408	0.284			

According to FFT analysis, the numbers indicate that the wider area means higher numbers. This study predicted that alpha and low beta scores will be increased after walking. Furthermore, the high beta frequency will be decreased. In general, the independent samples t-test results of FTT found no significant result related to the hypothesis (H1). According to the mean results, the high beta frequency was decreased in both settings. Before and after walking mean values of increasing alpha frequency were most seen in the channel of Pz in NL. Moreover, in NL, the channel of T8 had the most increased low beta frequency.

Table 16. Continued. The independent samples t-test for Pz-T7-T8 frequency band

Factors	Channels	Frequency Band	Conditions	M	SD	t	df	Sig. (2-tailed)
Natural Landscape	Pz	Alpha (α)	Before	9.536	3.987	-1.286	52	0.203
			After	11.358	6.186			
		Low Beta (β)	Before	11.538	7.081	-1.598	52	0.115
			After	16.416	14.183			
		High Beta (β)	Before	0.353	0.209	-0.911	52	0.366
			After	0.415	0.280			
	T7	Alpha (α)	Before	4.805	2.610	-0.444	52	0.658
			After	5.168	3.344			
		Low Beta (β)	Before	5.258	3.828	-1.481	52	0.144
			After	7.653	7.475			
		High Beta (β)	Before	0.135	0.071	-0.775	52	0.441
			After	0.152	0.095			
	T8	Alpha (α)	Before	12.250	11.150	-1.396	52	0.168
			After	18.469	20.279			
		Low Beta (β)	Before	18.213	26.123	-1.665	52	0.101
			After	47.255	86.785			
		High Beta (β)	Before	0.307	0.281	-1.735	52	0.088
			After	0.691	1.116			
Landscaped Garden	Pz	Alpha (α)	Before	23.312	49.405	0.066	52	0.947
			After	22.563	31.180			
		Low Beta (β)	Before	34.621	83.645	0.288	52	0.699
			After	28.069	26.259			
		High Beta (β)	Before	0.930	1.054	0.159	52	0.874
			After	0.888	0.912			
	T7	Alpha (α)	Before	15.519	42.494	-0.434	52	0.665
			After	20.208	36.442			
		Low Beta (β)	Before	25.563	80.517	-0.255	52	0.799
			After	30.157	47.499			
		High Beta (β)	Before	0.275	0.280	-1.157	52	0.252
			After	0.602	1.442			
	T8	Alpha (α)	Before	15.780	69.807	0.140	52	0.888
			After	13.482	48.704			
		Low Beta (β)	Before	28.601	12.421	0.455	52	0.650
			After	17.228	36.988			
		High Beta (β)	Before	1.773	4.100	-0.199	52	0.842
			After	1.979	3.442			

4.7. Discussion

This chapter discusses the findings of this study and its relations with the existing literature review. The main aim of this study was to understand the difference in the neurological, psychological, and psychophysiological influence of walking near water features in the natural landscape and landscaped garden environments. Determining the effects of such environments is crucial to design better surroundings for psychological well-being.

According to, SRT and ART research on nature may create light meditative states in daily life. In addition to these theories, this study asked the ‘RQ1: Are there any significant neurological differences between natural landscapes and landscaped gardens in terms of brainwaves from beta to alpha frequency in the frontal lobe?’. The findings demonstrated that the high beta frequency was decreased in both settings. Therefore, the lowest high beta score is seen in the LG more than in the NL. On the other side, both setting had increased low beta frequency but the NL had more than the LG. According to alpha frequency analysis, in LG the channel AF3 increased but the channel AF4 decreased. Therefore, in the NL both channels increased. Besides the before-after comparison of each channel, the results of alpha and low beta frequency areas in the LG are approximately two times more than NL. "H1: The high Beta brainwave frequency in the frontal lobe, which is related to the high-stress level, slows down from Alpha frequency after walking near the water feature in both natural landscapes and landscaped gardens" is not significantly supported.

The comparison of differences among sub-scales of POMS results showed that all sub-scales for both settings positively changed after walking. Particularly, the sub-scales of ‘Anxiety’ and ‘Tension’ had more positive changes than others. For TMD score analysis, before walking, scores were higher in the LG. However, both set has the potential to decrease TMD score. However, data analysis of results did not significantly support the "H2: Walking near the water features in landscaped gardens has a more significant restorative effect on the emotional state than in natural landscapes"

Data analysis of before-after performance metrics showed decreased stress and increased relaxation levels in both NL and LG. Therefore, a comparison of settings had significant changes between them. An earlier study indicated that densely wooded areas increased fear and stress levels (Gatersleben & Andrews, 2013). These findings can be supported by the previous ART and SRT research. The LG environment has a higher prospect and lowers refuge effects more than NL. In this study, the participants in NL experienced high levels of refuge and low levels of prospects, the main characteristics of woodland environments. On the other side, the LG setting has a greater prospect. For this reason, the participants in LG were more relaxed and had lower stress levels than those in NL. In performance metrics analysis, maximum and minimum scores showed that minimum scores were not significantly changed in both settings. Nevertheless, LG maximum scores changed to greater than NL. Especially, the LG maximum scores of relaxation dramatically decreased. For these findings, the restorative potential of the NL relaxation effect is less than LG. To conclude, these findings not significantly supported the “H3: Walking in landscaped gardens significantly differs in stress-relaxation levels from walking in natural landscapes”.

A previous study demonstrated a significant correlation between higher CNS scores and well-being (Mayer & Frantz, 2004). In this study, the CNS findings indicated that most of the participants had a medium connection to nature. Furthermore, Self-reported experience of nature results showed that most of the participants had a visual and physical connection to greenery areas. In addition, only 27 of 54 participants spend 1-3 hours a week in natural environments. However, approximately half of them had the habit of walking in there. There might be some correlation between interaction types that can increase or decrease CNS results.

According to the self-reported experience of nature, 43 of 57 participants reported that there are green areas close to the building where they spend the most time during the day. However, only 19 of them have a visual connection to those areas. Besides the close location of greenery areas, having a visual relationship with those areas is essential for both ART and SRT theories. Only visual connection with nature in daily life might great potential to decrease the level of stress. LG participants reported more visual relation in their daily routine than NL participants. Therefore, a better relaxation level in LG might be related to a visual connection with nature during the day. Additionally, physical relations as walking (Q4) reported more than half of the participants had the habit of walking in both parks and natural areas. However, spending time in nature per week (Q4) reports indicated that the most given answer was 1-3 hours means a low connection with nature. Even if the habit of walking in nature, the interaction duration in nature in daily life is more beneficial for psychological and neurological health.

CHAPTER 5

CONCLUSION

This study systematically analyzed the physiological, psychophysiological, and neurological impacts of walking in the natural landscape and landscaped garden environments. The experiment had physiological (POMS), psychophysiological (Performance Metrics), and neurological (EEG) measurements. According to interdisciplinary insight, using the latest technology to understand the connection between nature and humans, the oldest basic need, might have an essential role in preventing dissociation.

The earliest research, on the positive psychological effects of water features, was found by Herzog in 1985. Recent developments showed that environments with natural or artificial water related to higher preferences, and higher perceptions which increases the positive neurological effects of restorativeness than those without water environments (White et al., 2010). Furthermore, the more recent psychophysiological study of analyzing brain regions with fMRI during viewing photos of the different natural environments found that water and mountain environments have significantly more restorative than urban and woodland environments (Tang et al., 2017). However, the literature has not done enough systematic empirical research on the neurological effects of natural and artificial water elements. This research aims to provide the differences between natural and artificial water features.

The studies about the short-term effects of walking in natural environments indicate that 15 minutes of walking increases CNS scores (Mayer, Frantz, Bruehlman-Senecal & Dolliver, 2009) and 25 minutes increases the level of restoration (Cotie et al., 2018). Through data analysis, this study supported that 25 minutes. walking in natural environments positively influences psychological and neurological well-being. However, besides the short-term effects of walking in nature, longitudinal research should provide a progression of changes. For instance, the "30 minutes a day in nature for 30 days" experiment found significant increases in mood, well-being, and mindfulness (Hamann & Ivtzan, 2016). For this reason, future studies should design experiments with longer durations to examine neurological changes. This research clearly illustrates the difference between types of natural environments on human health but also raises the question: Are there any neurological differences among interaction types and durations with nature? Interdisciplinary studies like architecture, city, and regional planning with neurology have great potential to promote the relation of humans with the natural environments, macro to micro scales. In addition to academic studies, initial policy implications about increasing connection with nature to design high-quality landscaped gardens might improve a population's health and well-being (Van den Berg, Maas, Verheij & Groenewegen, 2010). A previous study demonstrated that not every natural environment has restorative effects (Gatersleben & Andrews, 2013). For this reason, high-quality landscaped gardens need to be redefined in terms of accessibility, variety of features (waters, plants), and architectural elements (prospect, refuge).

In the literature, many studies examined the positive effects of nature on human health. However, no study examined the different natural environments and natural features of neurological health. Therefore, this study is the first to classify the natural environments with natural landscapes and landscaped gardens with water features. The second strength of the study is the distinctive methodology decisions that contain neurological, psychological, and psychophysiological data collection and analysis. Moreover, previous studies found that interaction types with nature differently influence human well-being. Particularly, walking in natural environments improves mental and physical health (Sugiyama et al., 2008). For that reason, this study aimed to observe neurological and psychophysiological improvements in short-duration walking. To sum up, this comprehensive research with a multidisciplinary insight aimed to fill the gaps in the literature.

There are a few limitations of this study. The field-based studies contribute to greater improvements concerning nature (Tsunetsugu et al., 2013). However, the first limitation was that the characteristics of field-based experiments made environmental control difficult. For instance, the previous schedule of the experiment was organized in March. However, because of unpredictable rainy days, the experiment schedule was postponed to April. The second limitation was finding participants who had easy access to the setting and were willing to walk.

REFERENCES

Adli, M., Berger, M., Brakemeier, E. L., Engel, L., Fingerhut, J., Gomez-Carrillo, A., Hehl, R., Heinz, A., Mayer, J., Mehran, N., Tolaas, S., Walter, H., Weiland, U., & Stollmann, J. (2017). Neurourbanism: towards a new discipline. *The Lancet Psychiatry*, *4*(3), 183–185. https://doi.org/10.1016/S2215-0366(16)30371-6

Al-Barrak, L., Kanjo, E., & Younis, E. M. G. (2017). NeuroPlace: Categorizing urban places according to mental states. *PLoS ONE*, *12*(9), 1–21. https://doi.org/10.1371/journal.pone.0183890

Al-Fahoum, A. S., & Al-Fraihat, A. A. (2014). Methods of EEG Signal Features Extraction Using Linear Analysis in Frequency and Time-Frequency Domains. *ISRN Neuroscience*, *2014*, 1–7. https://doi.org/10.1155/2014/730218

Alvarsson, J. J., Wiens, S., & Nilsson, M. E. (2010). Stress recovery during exposure to nature sound and environmental noise. *International Journal of Environmental Research and Public Health*, *7*(3), 1036–1046. https://doi.org/10.3390/ijerph7031036

Amicone, G., Petruccelli, I., De Dominicis, S., Gherardini, A., Costantino, V., Perucchini, P., & Bonaiuto, M. (2018). Green Breaks: The restorative effect of the school environment's green areas on children's cognitive performance. *Frontiers in Psychology*, *9*(OCT), 1–15. https://doi.org/10.3389/fpsyg.2018.01579

Asakawa, S., Yoshida, K., & Yabe, K. (2004). Perceptions of urban stream corridors within the greenway system of Sapporo, Japan. *Landscape and Urban Planning*, *68*(2–3), 167–

Aspinall, P., Mavros, P., Coyne, R., & Roe, J. (2015). The urban brain: Analysing outdoor physical activity with mobile EEG. *British Journal of Sports Medicine*, *49*(4), 272–276. https://doi.org/10.1136/bjsports-2012-091877

Baker, F., Denniston, M., Zabora, J., Polland, A., & Dudley, W. N. (2002). A POMS short form for cancer patients: Psychometric and structural evaluation. *Psycho-Oncology*, *11*(4), 273–281. https://doi.org/10.1002/pon.564

Banaei, M., Hatami, J., Yazdanfar, A., & Gramann, K. (2017). Walking through architectural spaces: The impact of interior forms on human brain dynamics. *Frontiers in Human Neuroscience*, *11*(September), 1–14. https://doi.org/10.3389/fnhum.2017.00477

Barton, J., Hine, R., & Pretty, J. (2009). The health benefits of walking in greenspaces of high natural and heritage value. *Journal of Integrative Environmental Sciences, 6*(4), 261–278. https://doi.org/10.1080/19438150903378425

Berger, B. G., & Motl, R. W. (2000). Exercise and mood: A selective review and synthesis of research employing the profile of mood states. *Journal of Applied Sport Psychology*, *12*(1), 69–92. https://doi.org/10.1080/10413200008404214

Berman, M. G., Jonides, J., & Kaplan, S. (2008). The cognitive benefits of interacting with nature. *Psychological Science, 19*(12), 1207–1212. https://doi.org/10.1111/j.1467-9280.2008.02225.x

Berto, R. (2014). The role of nature in coping with psycho-physiological stress: A literature review on restorativeness. *Behavioral Sciences*, *4*(4), 394–409. https://doi.org/10.3390/bs4040394

Beute, F., & de Kort, Y. A. W. (2013). Let the sun shine! Measuring explicit and implicit preference for environments differing in naturalness, weather type and brightness. *Journal of Environmental Psychology*, *36*, 162–178. https://doi.org/10.1016/j.jenvp.2013.07.016

Biederman, I., & Vessel, E. (2006). Perceptual Pleasure and the Brain: A novel theory explains why the brain craves information and seeks it through the senses. *American Scientist*, *94*(3), 247–253. http://www.americanscientist.org/issues/issue.aspx?id=995&y=0&no=&content=true&page=4&css=print%5Cnpapers2://publication/uuid/593510F5-A7F5-47E2-837F-3B077E4EB0A9

Bratman, G. N., Daily, G. C., Levy, B. J., & Gross, J. J. (2015). The benefits of nature experience: Improved affect and cognition. *Landscape and Urban Planning*, *138*, 41–50. https://doi.org/10.1016/j.landurbplan.2015.02.005

Bratman, G. N., Hamilton, J. P., & Daily, G. C. (2012). The impacts of nature experience on human cognitive function and mental health. *Annals of the New York Academy of Sciences*, *1249*(1), 118–136. https://doi.org/10.1111/j.1749-6632.2011.06400.x

Burmil, S., Daniel, T. C., & Hetherington, J. D. (1999). Human values and perceptions of water in arid landscapes. *Landscape and Urban Planning*, *44*(2–3), 99–109. https://doi.org/10.1016/S0169-2046(99)00007-9

Buttazzoni, A., Veenhof, M., & Minaker, L. (2020). Smart city and high-tech urban interventions targeting human health: An equity-focused systematic review. *International Journal of Environmental Research and Public Health*, *17*(7), 1–23. https://doi.org/10.3390/ijerph17072325

Cerna, M., & Harvey, A. F. (2000). *<the_fundamentalsFFT processing.pdf>*. *July*, 1–20.

Choi, B. C., & Pak, A. W. (2007). Multidisciplinarity, interdisciplinarity, and transdisciplinarity in health research, services, education and policy: 2. Promotors, barriers, and strategies of enhancement. *Clinical and Investigative Medicine*, E224-E232.

Churchill, N. W., Spring, R., Grady, C., Cimprich, B., Askren, M. K., Reuter-Lorenz, P. A., Jung, M. S., Peltier, S., Strother, S. C., & Berman, M. G. (2016). The suppression of scale-free fMRI brain dynamics across three different sources of effort: Aging, task novelty and task difficulty. *Scientific Reports*, *6*(August), 1–16. https://doi.org/10.1038/srep30895

Cohen, S., & Rodriguez, M. S. (1995). Pathways linking affective disturbances and physical disorders. *Health psychology*, *14*(5), 374.

Cotie, L. M., Prince, S. A., Elliott, C. G., Ziss, M. C., McDonnell, L. A., Mullen, K. A., Hiremath, S., Pipe, A. L., Reid, R. D., & Reed, J. L. (2018). The effectiveness of eHealth interventions on physical activity and measures of obesity among working-age women: a systematic review and meta-analysis. *Obesity Reviews*, *19*(10), 1340–1358. https://doi.org/10.1111/obr.12700

Dahmann, N., Wolch, J., Joassart-Marcelli, P., Reynolds, K., & Jerrett, M. (2010). The active city? Disparities in provision of urban public recreation resources. *Health and Place*, *16*(3), 431–445. https://doi.org/10.1016/j.healthplace.2009.11.005

De Paiva, A., & Jedon, R. (2019). Short- and long-term effects of architecture on the brain:

Toward theoretical formalization. *Frontiers of Architectural Research, 8*(4), 564–571. https://doi.org/10.1016/j.foar.2019.07.004

Delorme, A., & Makeig, S. (2004). EEGLAB: An open source toolbox for analysis of single-trial EEG dynamics including independent component analysis. *Journal of Neuroscience Methods, 134*(1), 9–21. https://doi.org/10.1016/j.jneumeth.2003.10.009

Dispenza, J. (2013). *Breaking the habit of being yourself: How to lose your mind and create a new one*. Hay House, Inc.

Edelstein, E. (2016). Neuroscience and architecture. *The Routledge Companion for Architecture Design and Practice: Established and Emerging Trends,* 269–288. https://doi.org/10.4324/9781315775869

Evans, G.W. & Cohen, S. (1987). Environmental stress. In D. Stokols & I. Altman, Eds., Handbook of Environmental Psychology (2 Vols) New York: John Wiley, pp 571-610.

Felsten, G. (2009). Where to take a study break on the college campus: An attention restoration theory perspective. *Journal of Environmental Psychology*, *29*(1), 160–167. https://doi.org/10.1016/j.jenvp.2008.11.006

Fisher, M. J., & Marshall, A. P. (2009). Understanding descriptive statistics. *Australian critical care*, *22*(2), 93-97.

Frumkin, H., Bratman, G. N., Breslow, S. J., Cochran, B., Kahn, P. H., Lawler, J. J., Levin, P. S., Tandon, P. S., Varanasi, U., Wolf, K. L., & Wood, S. A. (2017). Nature contact and human health: A research agenda. *Environmental Health Perspectives*, *125*(7), 1–18. https://doi.org/10.1289/EHP1663

Frumkin, H., Frank, L., Frank, L. D., & Jackson, R. J. (2004). *Urban sprawl and public health: Designing, planning, and building for healthy communities*. Island Press.

Fuchs, E., & Flügge, G. (2014). Adult neuroplasticity: More than 40 years of research. *Neural Plasticity*, *2014*. https://doi.org/10.1155/2014/541870

Fuller, R. A., Irvine, K. N., Devine-Wright, P., Warren, P. H., & Gaston, K. J. (2007). Psychological benefits of greenspace increase with biodiversity. *Biology Letters, 3*(4), 390–394. https://doi.org/10.1098/rsbl.2007.0149

Gascon, M., Zijlema, W., Vert, C., White, M. P., & Nieuwenhuijsen, M. J. (2017). Outdoor blue spaces, human health and well-being: A systematic review of quantitative studies. *International Journal of Hygiene and Environmental Health*, *220*(8), 1207–1221. https://doi.org/10.1016/j.ijheh.2017.08.004

Gatersleben, B., & Andrews, M. (2013). When walking in nature is not restorative-The role of prospect and refuge. *Health and Place*, *20*, 91–101. https://doi.org/10.1016/j.healthplace.2013.01.001

Gegenfurtner, A., Kok, E. M., Van Geel, K., de Bruin, A. B., & Sorger, B. (2017). Neural correlates of visual perceptual expertise: Evidence from cognitive neuroscience using functional neuroimaging. *Frontline Learning Research*, *5*(3), 14-30.

Ghamari, H., Golshany, N., Rad, P. N., & Behzadi, F. (2021). Neuroarchitecture assessment: An overview and bibliometric analysis. *European Journal of Investigation in Health, Psychology and Education*, *11*(4), 1362–1387. https://doi.org/10.3390/ejihpe11040099

Gidlow, C. J., Jones, M. V., Hurst, G., Masterson, D., Clark-Carter, D., Tarvainen, M. P., Smith, G., & Nieuwenhuijsen, M. (2016). Where to put your best foot forward: Psycho-physiological responses to walking in natural and urban environments. *Journal of Environmental Psychology*, *45*, 22–29. https://doi.org/10.1016/j.jenvp.2015.11.003

Gu, Y., & Bollen, M. H. J. (2000). Time-frequency and time-scale domain analysis of voltage disturbances. *IEEE Transactions on Power Delivery*, *15*(4), 1279–1284. https://doi.org/10.1109/61.891515

Hamann, G. A., & Ivtzan, I. (2016). Social Inquiry into Well-Being 30 Minutes in Nature a Day Can Increase Mood, Well-Being, Meaning in Life and Mindfulness: Effects of a Pilot Programme. *Social Inquiry into Well-Being*, *2*(2), 34–46. https://doi.org/10.13165/SIIW-16-2-2-04

Hartig, T., Evans, G. W., Jamner, L. D., Davis, D. S., & Gärling, T. (2003). Tracking restoration in natural and urban field settings. *Journal of Environmental Psychology*, *23*(2), 109–123. https://doi.org/10.1016/S0272-4944(02)00109-3

Hartig, T., Mang, M., & Evans, G. W. (1991). Restorative effects of natural environment experiences. *Environment and behavior*, *23*(1), 3-26.

Herzog, T. R., & Barnes, G. J. (1999). Tranquility and preference revisited. *Journal of Environmental Psychology*, *19*(2), 171–181. https://doi.org/10.1006/jevp.1998.0109

Heunis, C. (2016). *Export and Analysis of Emotiv Insight EEG Data via EEGLAB*. *July*, 1–11. https://doi.org/10.13140/RG.2.1.3081.4326

Hirsch, G. V, Bauer, C. M., & Merabet, L. B. (2015). Using structural and functional brain imaging to uncover how the brain adapts to blindness. *Journal of Psychiatry and Brain Functions*, *2*(1), 7. https://doi.org/10.7243/2055-3447-2-7

Hollander, J., & Foster, V. (2016). Brain responses to architecture and planning: A preliminary neuro-assessment of the pedestrian experience in Boston, Massachusetts. *Architectural science review*, *59*(6), 474-481.

Homolja, M., Maghool, S. A. H., & Schnabel, M. A. (2020). The impact of moving through the built environment on emotional and neurophysiological state: A systematic literature review. *RE: Anthropocene, Design in the Age of Humans - Proceedings of the 25th International Conference on Computer-Aided Architectural Design Research in Asia, CAADRIA 2020*, *1*(October), 641–650.

Hu, M., Simon, M., Fix, S., Vivino, A. A., & Bernat, E. (2021). Exploring a sustainable building's impact on occupant mental health and cognitive function in a virtual environment. *Scientific Reports*, *11*(1), 1–13. https://doi.org/10.1038/s41598-021-85210-9

Johansson, M., Hartig, T., & Staats, H. (2011). Psychological benefits of walking: Moderation by company and outdoor environment. *Applied Psychology: Health and Well-Being*, *3*(3), 261–280. https://doi.org/10.1111/j.1758-0854.2011.01051.x

Joye, Y., & Dewitte, S. (2018). Nature's broken path to restoration. A critical look at Attention Restoration Theory. *Journal of Environmental Psychology*, *59*(March), 1–8. https://doi.org/10.1016/j.jenvp.2018.08.006

Kaplan, R., Kaplan, S., & Brown, T. (1989). Environmental Preference: A Comparison of Four Domains of Predictors. *Environment and Behavior*, *21*(5), 509–530. https://doi.org/10.1177/0013916589215001

Kaplan, S. (1995). The restorative benefits of nature: Toward an integrative framework. *Journal of Environmental Psychology*, *15*(3), 169–182. https://doi.org/10.1016/0272-4944(95)90001-2

Karmanov, D., & Hamel, R. (2008). Assessing the restorative potential of contemporary urban environment(s): Beyond the nature versus urban dichotomy. *Landscape and Urban Planning, 86*(2), 115–125. https://doi.org/10.1016/j.landurbplan.2008.01.004

Keniger, L. E., Gaston, K. J., Irvine, K. N., & Fuller, R. A. (2013). What are the benefits of interacting with nature? *International Journal of Environmental Research and Public Health*, *10*(3), 913–935. https://doi.org/10.3390/ijerph10030913

Keshavarz, B., Campos, J. L., & Berti, S. (2015). Vection lies in the brain of the beholder: EEG parameters as an objective measurement of vection. *Frontiers in Psychology*, *6*(OCT). https://doi.org/10.3389/fpsyg.2015.01581

Khudiakov, G. I. (2008). Sampling theorem in signal theory and its originators. *Journal of Communications Technology and Electronics*, *53*(9), 1096–1106. https://doi.org/10.1134/S1064226908090118

Klepeis, N. E., Nelson, W. C., Ott, W. R., Robinson, J. P., Tsang, A. M., Switzer, P., Behar, J. V., Hern, S. C., & Engelmann, W. H. (2001). The National Human Activity Pattern Survey (NHAPS): A resource for assessing exposure to environmental pollutants. *Journal of Exposure Analysis and Environmental Epidemiology*, *11*(3), 231–252. https://doi.org/10.1038/sj.jea.7500165

Koehl, M., & Abrous, D. N. (2011). A new chapter in the field of memory: Adult hippocampal neurogenesis. *European Journal of Neuroscience, 33*(6), 1101–1114. https://doi.org/10.1111/j.1460-9568.2011.07609.x

Laumann, K., Gärling, T., & Stormark, K. M. (2001). Rating scale measures of restorative components of environments. *Journal of Environmental Psychology*, *21*(1), 31–44. https://doi.org/10.1006/jevp.2000.0179

Lederbogen, F., Kirsch, P., Haddad, L., Streit, F., Tost, H., Schuch, P., Wüst, S., Pruessner, J. C., Rietschel, M., Deuschle, M., & Meyer-Lindenberg, A. (2011). City living and urban upbringing affect neural social stress processing in humans. *Nature*, *474*(7352), 498–501. https://doi.org/10.1038/nature10190

Li, J., Jin, Y., Lu, S., Wu, W., & Wang, P. (2020). Building environment information and human perceptual feedback collected through a combined virtual reality (VR) and electroencephalogram (EEG) method. *Energy and Buildings*, *224*. https://doi.org/10.1016/j.enbuild.2020.110259

Logothetis, N. K., Pauls, J., Augath, M., Trinath, T., & Oeltermann, A. (2001). Neurophysiological investigation of the basis of the fMRI signal. *nature*, *412*(6843), 150-157.

Luttik, J. (2000). The value of trees, water and open space as reflected by house prices in the Netherlands. *Landscape and Urban Planning*, *48*(3–4), 161–167. https://doi.org/10.1016/S0169-2046(00)00039-6

MacKerron, G., & Mourato, S. (2013). Happiness is greater in natural environments. *Global Environmental Change*, *23*(5), 992–1000. https://doi.org/10.1016/j.gloenvcha.2013.03.010

Makeig, S., & Jung, T. (2000). Independent Component Analysis of Simulated ERP Data. *Brain*, *January*, 1–24. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.91.329&rep=rep1&type=pdf

Markevych, I., Schoierer, J., Hartig, T., Chudnovsky, A., Hystad, P., Dzhambov, A. M., de Vries, S., Triguero-Mas, M., Brauer, M., Nieuwenhuijsen, M. J., Lupp, G., Richardson, E. A., Astell-Burt, T., Dimitrova, D., Feng, X., Sadeh, M., Standl, M., Heinrich, J., & Fuertes, E. (2017). Exploring pathways linking greenspace to health: Theoretical and methodological guidance. *Environmental Research*, *158*(June), 301–317. https://doi.org/10.1016/j.envres.2017.06.028

Mayer, F. S., & Frantz, C. M. P. (2004). The connectedness to nature scale: A measure of individuals’ feeling in community with nature. *Journal of Environmental Psychology*, *24*(4), 503–515. https://doi.org/10.1016/j.jenvp.2004.10.001

Mayer, F. S., Frantz, C. M. P., Bruehlman-Senecal, E., & Dolliver, K. (2009). Why is nature beneficial?: The role of connectedness to nature. *Environment and Behavior*, *41*(5), 607–643. https://doi.org/10.1177/0013916508319745

McNair, D. M., Lorr, M., & Droppleman, L. F. (1971). Manual for the profile of mood states. San Diego: Educational and Industrial Testing Services.

Menardo, E., Brondino, M., Hall, R., & Pasini, M. (2021). Restorativeness in Natural and Urban Environments: A Meta-Analysis. *Psychological Reports*, *124*(2), 417–437. https://doi.org/10.1177/0033294119884063

Micheva, K. D., Busse, B., Weiler, N. C., O'Rourke, N., & Smith, S. J. (2010). Single-synapse analysis of a diverse synapse population: Proteomic imaging methods and markers. *Neuron*, *68*(4), 639–653. https://doi.org/10.1016/j.neuron.2010.09.024

Murugappan, M., Murugappan, S., Balaganapathy, B., & Gerard, C. (2014). Wireless EEG signals based Neuromarketing system using Fast Fourier Transform (FFT). *Proceedings - 2014 IEEE 10th International Colloquium on Signal Processing and Its Applications, CSPA 2014*, 25–30. https://doi.org/10.1109/CSPA.2014.6805714

Nguyen, T. A., & Zeng, Y. (2014). A physiological study of relationship between designer's mental effort and mental stress during conceptual design. *Computer-Aided Design*, *54*, 3-18.

Norwood, M. F., Lakhani, A., Maujean, A., Zeeman, H., Creux, O., & Kendall, E. (2019). Brain activity, underlying mood and the environment: A systematic review. *Journal of Environmental Psychology*, *65*(June), 101321. https://doi.org/10.1016/j.jenvp.2019.101321

Nowak, D. J., Crane, D. E., & Stevens, J. C. (2006). Air pollution removal by urban trees and shrubs in the United States. *Urban Forestry and Urban Greening*, *4*(3–4), 115–123. https://doi.org/10.1016/j.ufug.2006.01.007

Nutsford, D., Pearson, A. L., Kingham, S., & Reitsma, F. (2016). Residential exposure to visible blue space (but not green space) associated with lower psychological distress in a capital city. *Health and Place*, *39*, 70–78. https://doi.org/10.1016/j.healthplace.2016.03.002

Pantev, C., Elbert, T., Makeig, S., Hampson, S., Eulitz, C., & Hoke, M. (1993). Relationship of transient and steady-state auditory evoked fields. *Electroencephalography and Clinical Neurophysiology/Evoked Potentials Section*, *88*(5), 389-396.

Papale, P., Chiesi, L., Rampinini, A. C., Pietrini, P., & Ricciardi, E. (2016). When neuroscience "touches" architecture: From hapticity to a supramodal functioning of the human brain. *Frontiers in Psychology*, *7*(JUN), 1–8. https://doi.org/10.3389/fpsyg.2016.00866

Pasanen, T. P., White, M. P., Wheeler, B. W., Garrett, J. K., & Elliott, L. R. (2019). Neighbourhood blue space, health and wellbeing: The mediating role of different types of physical activity. *Environment International*, *131*(June). https://doi.org/10.1016/j.envint.2019.105016

Pati, D., O'Boyle, M., Hou, J., Nanda, U., & Ghamari, H. (2016). Can Hospital Form Trigger Fear Response? *Health Environments Research and Design Journal*, *9*(3), 162–175. https://doi.org/10.1177/1937586715624210

Peen, J., Schoevers, R. A., Beekman, A. T., & Dekker, J. (2010). The current status of urban-rural differences in psychiatric disorders. *Acta Psychiatrica Scandinavica*, *121*(2), 84–93. https://doi.org/10.1111/j.1600-0447.2009.01438.x

Phan, K. L., Wager, T., Taylor, S. F., & Liberzon, I. (2002). Functional neuroanatomy of emotion: a meta-analysis of emotion activation studies in PET and fMRI. *Neuroimage*, *16*(2), 331-348.

Pykett, J., Osborne, T., & Resch, B. (2020). From Urban Stress to Neurourbanism: How Should We Research City Well-Being? *Annals of the American Association of Geographers*, *110*(6), 1936–1951. https://doi.org/10.1080/24694452.2020.1736982

Rad, P. N., Behzadi, F., Yazdanfar, A., Ghamari, H., Zabeh, E., & Lashgari, R. (2021). *Cognitive and perceptual influences of architectural and urban environments with an emphasis on the experimental procedures and techniques*.

Regan, C. L., & Horn, S. A. (2005). To nature or not to nature: Associations between environmental preferences, mood states and demographic factors. *Journal of Environmental Psychology*, *25*(1), 57–66. https://doi.org/10.1016/j.jenvp.2005.01.001

Roach, B. J., & Mathalon, D. H. (2008). Event-related EEG time-frequency analysis: An overview of measures and an analysis of early gamma band phase locking in schizophrenia. *Schizophrenia Bulletin*, *34*(5), 907–926. https://doi.org/10.1093/schbul/sbn093

Roe, J. J., Ward Thompson, C., Aspinall, P. A., Brewer, M. J., Duff, E. I., Miller, D., Mitchell, R., & Clow, A. (2013). Green space and stress: Evidence from cortisol measures in deprived urban communities. *International Journal of Environmental Research and Public Health*, *10*(9), 4086–4103. https://doi.org/10.3390/ijerph10094086

Ronghua, W., Zhao, J., Meitner, M. J., Hu, Y., & Xu, X. (2019). Characteristics of urban green spaces in relation to aesthetic preference and stress recovery. *Urban Forestry and*

Urban Greening, *41*(101), 6–13. https://doi.org/10.1016/j.ufug.2019.03.005

Rosenbaum, M. S., Ramírez, G. C., & Matos, N. (2019). A neuroscientific perspective of consumer responses to retail greenery. *Service Industries Journal*, *39*(15–16), 1034–1045. https://doi.org/10.1080/02642069.2018.1487406

Sampson, S. D. (2013). Ecopsychology and the third crisis. *Ecopsychology*, *5*(4), 212–214. https://doi.org/10.1089/eco.2013.0064

Shanahan, D. F., Bush, R., Gaston, K. J., Lin, B. B., Dean, J., Barber, E., & Fuller, R. A. (2016). Health Benefits from Nature Experiences Depend on Dose. *Scientific Reports*, *6*(February), 1–10. https://doi.org/10.1038/srep28551

Smith, D. G., Croker, G. F., & McFarlane, K. (1995). Human perception of water appearance: 1. Clarity and colour for bathing and aesthetics. *New Zealand Journal of Marine and Freshwater Research*, *29*(1), 29–43. https://doi.org/10.1080/00288330.1995.9516637

Solomon, S., Rosenlof, K. H., Portmann, R. W., Daniel, J. S., Davis, S. M., Sanford, T. J., & Plattner, G. K. (2010). Contributions of stratospheric water vapor to decadal changes in the rate of global warming. *Science*, *327*(5970), 1219–1223. https://doi.org/10.1126/science.1182488

Strang, V. (2020). The Meaning of Water. *The Meaning of Water*. https://doi.org/10.4324/9781003087090

Strauss, K., Lepoutre, J., & Wood, G. (2017). Fifty shades of green: How microfoundations of sustainability dynamic capabilities vary across organizational contexts. *Journal of Organizational Behavior*, *38*(9), 1338–1355. https://doi.org/10.1002/job.2186

Sugiyama, T., Leslie, E., Giles-Corti, B., & Owen, N. (2008). Associations of neighbourhood greenness with physical and mental health: do walking, social coherence and local social interaction explain the relationships? *Journal of Epidemiology and Community Health*, *62*(5). https://doi.org/10.1136/jech.2007.064287

Tang, I. C., Tsai, Y. P., Lin, Y. J., Chen, J. H., Hsieh, C. H., Hung, S. H., Sullivan, W. C., Tang, H. F., & Chang, C. Y. (2017). Using functional Magnetic Resonance Imaging (fMRI) to analyze brain region activity when viewing landscapes. *Landscape and Urban Planning*, *162*, 137–144. https://doi.org/10.1016/j.landurbplan.2017.02.007

Teplan, M., & Institute. (2012). Fundamentals of Eeg Measurement M. *AAAI Fall Symposium*

- *Technical Report*, *FS-12-04*(2), 59–64.

Tsunetsugu, Y., Lee, J., Park, B. J., Tyrväinen, L., Kagawa, T., & Miyazaki, Y. (2013). Physiological and psychological effects of viewing urban forest landscapes assessed by multiple measurements. *Landscape and Urban Planning*, *113*, 90–93. https://doi.org/10.1016/j.landurbplan.2013.01.014

Tyrväinen, L., Ojala, A., Korpela, K., Lanki, T., Tsunetsugu, Y., & Kagawa, T. (2014). The influence of urban green environments on stress relief measures: A field experiment. *Journal of Environmental Psychology*, *38*, 1–9. https://doi.org/10.1016/j.jenvp.2013.12.005

Ulrich, R. (2008). Effects of healthcare acoustics on medical outcomes. *The Journal of the Acoustical Society of America*, *123*(5), 3094–3094. https://doi.org/10.1121/1.2932937

Ulrich, R. S., & Addoms, D. L. (1981). Psychological and recreational benefits of a residential park. *Journal of Leisure Research*, *13*(1), 43–65. https://doi.org/10.1080/00222216.1981.11969466

Ulrich, Roger S. (1979). Visual Landscapes and Psychological Weil-Being. *Landscape Research*, *4*(1), 17–23. https://doi.org/10.1080/01426397908705892

Ulrich, Roger S., Simons, R. F., Losito, B. D., Fiorito, E., Miles, M. A., & Zelson, M. (1991). Stress recovery during exposure to natural and urban environments. *Journal of Environmental Psychology*, *11*(3), 201–230. https://doi.org/10.1016/S0272-4944(05)80184-7

Valdez, G. F. D., Cayaban, A. R. R., Al-Fayyadh, S., Korkmaz, M., Obeid, S., Sanchez, C. L. A., Ajzoon, M. B., Fouly, H., & Cruz, J. P. (2020). The utilization of social networking sites, their perceived benefits and their potential for improving the study habits of nursing students in five countries. *BMC Nursing*, *19*(1), 1–15. https://doi.org/10.1186/s12912-020-00447-5

van den Berg, A. E., Maas, J., Verheij, R. A., & Groenewegen, P. P. (2010). Green space as a buffer between stressful life events and health. *Social Science and Medicine*, *70*(8), 1203–1210. https://doi.org/10.1016/j.socscimed.2010.01.002

Van der Smissen, B., & Christiansen, M. L. (1976). Standards Related to Water-oriented and Water-enhanced Recreation in Watersheds: Phase 1: Institute for Research on Land and

Water Resources, Pennsylvania State University.

Vartanian, O., Navarrete, G., Chatterjee, A., Fich, L. B., Leder, H., Modrono, C., Nadal, M., Rostrup, N., & Skov, M. (2013). Impact of contour on aesthetic judgments and approach-avoidance decisions in architecture. *Proceedings of the National Academy of Sciences of the United States of America*, *110*(SUPPL2), 10446–10453. https://doi.org/10.1073/pnas.1301227110

Vlahov, D., Galea, S., & Freudenberg, N. (2005). The urban health "advantage." *Journal of Urban Health*, *82*(1), 1–4. https://doi.org/10.1093/jurban/jti001

Völker, S., & Kistemann, T. (2011). The impact of blue space on human health and well-being - Salutogenetic health effects of inland surface waters: A review. *International Journal of Hygiene and Environmental Health*, *214*(6), 449–460. https://doi.org/10.1016/j.ijheh.2011.05.001

White, M. P., Pahl, S., Ashbullby, K., Herbert, S., & Depledge, M. H. (2013). Feelings of restoration from recent nature visits. *Journal of Environmental Psychology*, *35*, 40–51. https://doi.org/10.1016/j.jenvp.2013.04.002

White, M. P., Pahl, S., Wheeler, B. W., Depledge, M. H., & Fleming, L. E. (2017). Natural environments and subjective wellbeing: Different types of exposure are associated with different aspects of wellbeing. *Health and Place*, *45*(January), 77–84. https://doi.org/10.1016/j.healthplace.2017.03.008

White, M., Smith, A., Humphryes, K., Pahl, S., Snelling, D., & Depledge, M. (2010). Blue space: The importance of water for preference, affect, and restorativeness ratings of natural and built scenes. *Journal of Environmental Psychology, 30*(4), 482–493. https://doi.org/10.1016/j.jenvp.2010.04.004

Zelikowsky, M., Hersman, S., Chawla, M. K., Barnes, C. A., & Fanselow, M. S. (2014). Neuronal ensembles in amygdala, hippocampus, and prefrontal cortex track differential components of contextual fear. *Journal of neuroscience*, *34*(25), 8462-8466.

Zhang, W., He, X., Liu, S., Li, T., Li, J., Tang, X., & Lai, S. (2019). Neural correlates of appreciating natural landscape and landscape garden: Evidence from an fMRI study. *Brain and Behavior*, *9*(7), 1–10. https://doi.org/10.1002/brb3.1335

APPENDICES

A. APPROVED ETHICS FORMS BY BILKENT UNIVERSITY

Bilkent Üniversitesi
Akademik İşler Rektör Yardımcılığı

Tarih : 18 Ocak 2022

Gönderilen : Fulya Tolunay

Tez Danışmanı : Yasemin Afacan

Gönderen : H. Altay Güvenir
İnsan Araştırmaları Etik Kurulu Başkanı

Konu : *"The Neurological ..."* çalışması etik kurul onayı

Üniversitemiz İnsan Araştırmaları Etik Kurulu, 18 Ocak 2022 tarihli görüşme sonucu, *"The Neurological and Emotional Effects of Human and Nature Interaction: Walking in Natural Landscapes and Landscape Gardens and Analyses of Changing Brainwaves in Alpha and Beta Band"* isimli çalışmanız kapsamında yapmayı önerdiğiniz etkinlik için etik onay vermiş bulunmaktadır. Onay, ekte verilmiş olan çalışma önerisi, çalışma yürütücüleri ve bilgilendirme formu için geçerlidir.

Bu onay, yapmayı önerdiğiniz çalışmanın genel bilim etiği açısından bir değerlendirmedir. Çalışmanızda, kurulumuzun değerlendirmesi dışında kalabilen özel etik ve yasal sınırlamalara uymakla ayrıca yükümlüsünüz.

Kovid-19 salgını nedeniyle konulmuş olan kısıtlamaların yürürlükte olduğu süre içinde, tüm komite toplantıları elektronik ortamda yapılmaktadır; aşağıda isimleri bulunan Bilkent Üniversitesi Etik Kurulu Üyeleri adına bu yazıyı imzalama yetkisi kurul başkanındadır.

Etik Kurul Üyeleri:

Ünvan / İsim	**Bölüm / Uzmanlık**	
Prof.Dr. H. Altay Güvenir	Bilgisayar Mühendisliği	Başkan
Prof.Dr. Erdal Onar	Hukuk	Üye
Prof.Dr. Haldun Özaktaş	Elektrik ve Elektronik Müh.	Üye
Doç.Dr. Işık Yuluğ	Moleküler Biyoloji ve Genetik	Üye
Dr. Öğr. Üyesi Burcu Ayşen Ürgen	Psikoloji	Üye
Doç.Dr. Çiğdem Gündüz Demir	Bilgisayar Mühendisliği	Yedek Üye
Dr. Öğr. Üyesi A.Barış Özbilen	Hukuk	Yedek Üye

Kurul karar/toplantı No: 2022_01_18_02

(vi) **Consent** Informed consent must be obtained for all participants before they take part in your project. The form should clearly state what they will be doing, drawing attention to anything they could conceivably object to subsequently. It should be in a language that the person signing it will understand. It should also state that they can withdraw from the study at any time and the measures you are taking to ensure the confidentiality of data. If children are recruited from schools you will require the permission of the headteacher, and of parents. Children over 14 years should also sign an individual consent form themselves. When testing children you will also need Criminal Records Bureau clearance. Testing to be carried out in any institution (prison, hospital, etc.) will require permission from the appropriate authority. (Please include documentation for such permission.)
Who will you seek permission from?

Participants' full permission will be obtained prior to the experiment. All participants will be aged between 18 and 35 years old.

Please attach the consent form you will use. Write the "brief description of the study" in the words that you will use to inform the participants here.

The experiment will be conducted in the METU forest area and ParkOran residential area (real environment experiment).

The experiment has two main groups which are natural landscape(METU forest area) and landscape garden (ParkOran residential area). These main groups are also divided into walking paths with water features and without a water features. Each group has 30 participants and the total number of the experiment is 120. The variable in the study is the environment so that the designs procedure same as each other.

No personal information will be released at any stage of this research and all your data will be held in confidence by the researcher and will be deleted after analyzing the data. Moreover, you will be given instructions about the Emotiv Insight prior to the experiment.

(vii) **Debriefing - how and when will participants be informed about the experiment, and what information do you intend to provide? If there is any chance that a participant will be 'upset' by taking part in the experiment what measures will you take to mitigate this?**

Participants will be briefed about the study prior to the experiment. Then, each participant will be asked to read and sign a consent form, which explains the procedure. Also, prior to the experiment, they will be given instructions about wearing the Emotiv Insight for the experiment.

(viii) **What procedures will you follow in order to guarantee the confidentiality of participants' data?** Personal data (name, addresses, etc.) should only be stored if absolutely necessary and then only in such a way that they cannot be associated with the participant's experimental data.

All the participants of the study will be asked to sign a consent form to satisfy ethical procedures (See consent form attached). The names of the participants will be coded into numbers. All personal information of participants obtained during the research will be held in confidence by the researcher. In the informed consent form, there is a statement which is signed by the graduate student and the supervisor that "we confirm that the confidentiality and anonymity will be maintained and the participant will not be identified from any publications".

(vii) **Give brief details of other special issues the ethics committee should be aware of.**

(viii) **Tick any of the following that applies to your project**

[x] it uses Bilkent facilities;
[ ] it uses stimuli designed to be emotive or aversive;
[ ] it requires participants to ingest substances (e.g., alcohol);
[ ] it requires participants to give information of a personal nature;
[ ] it involves children or other vulnerable individuals;
[ ] it could put you or someone else at risk of injury.

2

19/01/22
UK.

(Form Student_EN[1*])

Ethics form for graduate and undergraduate students - human participants

Note - group projects fill in one copy with all your names on it. Consult your project supervisor for advice before filling in the form.

Your name(s): Fulya Tolunay

Project Supervisor: Assoc. Prof. Dr. Yasemin Afacan,

A. Write your name(s) and that of your supervisor above.

B. Read section 2 that your supervisor will have to sign. Make sure that you cover all these issues in section 1. Discuss what you are going to put on the form with your project supervisor.

C. Sign the form and get your project supervisor to complete section 2 and sign the form.

1. Project Outline (to be completed by the student(s))

(i) Full Title of Project:

The Neurological and Emotional Effects of Human and Nature Interaction: Walking in Natural Landscapes and Landscape Gardens and Analyses of Changing Brainwaves in Alpha and Beta Band

(ii) Aims of project:

To examine the neurological and emotional difference between natural landscapes and landscaped gardens (alpha and beta frequency).

(iii) What will the participants have to do? (brief outline of procedure; please draw attention to any manipulation that could possibly be judged as a deception; *for survey work, a copy of the survey should be attached to this form*):

The experiment has a between-subject design type so that the participant randomly selected the setting areas. After determination of the setting and time, the participant and researcher meet there. The experiment procedure stated with giving brief explanations to the participant and giving time for restoration and adaptation to the environment. Then Collecting EEG Raw data with the Emotiv insight device (3 mins.) and gave a written survey(Profile of Mood States Questionnaire (POMS) and The connectedness to nature scale (CNS)). Each set has a different scheduled road so the participant will walk approximately 25 mins. Then repeating the EEG Rwa data collection and written surveys. The final part of the experiment is the giving demographic survey form.

(iv) What sort of people will the participants be and how will they be recruited? In the case of children state age range. (*Any participant who has not lived through his/her 18th birthday is considered to be a child!*)

The participants of this study selected snowball and random sampling methods. The minimum number of participants will be 120 people are aged between 18-35.

*If you are testing children or other vulnerable individuals, state whether all applicants have CRB[2**] clearance*

(v) What sort of stimuli or materials will your participants be exposed to? Tick the appropriate boxes and then explain the form that they take in the space below, please draw attention to any content that could conceivably upset your participants).

Questionnaires[x]; Pictures[ ]; Sounds [ ]; Words[ ]; Caffeine[ ]; Alcohol[ ]; Other[x].

Emotiv Insight for EEG Raw data max. wearing duration is 6 mins. There is no side effects.

1* Adapted from *www.york.ac.uk/depts/psych/www/research/ethics/HumanProjForm.doc*

2* * Criminal Records Bureau – Please attach relevant clearance documentation.

1

19/01/22

Student's signature: Fulya Tolunay Date: 19.01.2022
(all students must sign if this is a group project, please initial all other pages)

The signatures here signify that researchers will conform to the accepted ethical principles endorsed by relevant professional bodies, in particular to

Declaration of Helsinki (WMA):
http://www.wma.net/en/30publications/10policies/b3/index.html

Ethical Principles of Psychologists and Code of Conduct (APA):
http://www.apa.org/ethics/code2002.html

Ethical Standards for Research with Children (SCRD):
http://www.srcd.org/about-us/ethical-standards-research

2. Supervisor's assessment (supervisor to complete - circle yes or no)

Yes/No - I confirm that I have secured the resources required by this project, including any workshop time, equipment, or space that are additional to those already allocated to me.

Yes/No - The design of this study ensures that the dignity, welfare and safety of the participants will be ensured and that if children or other vulnerable individuals are involved they will be afforded the necessary protection.

Yes/No - All statutory, legislative and other formal requirements of the research have been addressed (e.g., permissions, police checks)

Yes/No - I am confident that the participants will be provided with all necessary information before the study, in the consent form, and after the study in debriefing.

Yes/No - I am confident the participant's confidentiality will be preserved.

Yes/No - I confirm that the students involved have sufficient professional competency for this project.

Yes/No - I consider that the risks involved to the student, the participants, and any third party are insignificant and carry no special supervisory considerations. If you circle "no" please attach an explanatory note.

No/Yes - I would like the ethics committee to give this proposal particular attention. (Please state why below)

Supervisor's signature:.............................. Date: ....19.01.22....................

Please e-mail an electronic version of this word-processed form (without signatures) along with other application material to the committee to start the evaluation process. **Paper copies of all application material, (properly signed where indicated, and initialed on all other pages) should be sent after possible modifications suggested by the committee are finalized.**

Bilkent University does not allow the use of students of research investigators as participants. Students who have the potential of being graded by the investigators during or following the semester(s) in which the study is being carried out should not participate in the study. Students may not receive any credit for any university course, with the exception of the GE250/GE251 courses, for their participation. The GE250 and GE251 (Collegiate Activities I and II) courses include an optional activity that encompasses volunteering as a participant in a research project.

19/01/22

Bilkent University Informed Consent Form

Please fill in the blanks after reading the form carefully.

1	**Name and Surname of the participant:**	______
2	**The contact information (address, e-mail, mobile phone) of the person chosen by the participant in case of any trouble**	______

Name of the Research:

The Neurological and Emotional Effects of Human and Nature Interaction: Walking in Natural Landscapes and Landscape Gardens and Analyses of Changing Brainwaves in Alpha and Beta Band

The aim, method, and expected benefits of the research

The main research aim is that examine the neurological and emotional difference between natural landscapes and landscaped gardens (alpha and beta frequency). To underline the importance of nature experience for both protection natural landscapes and increasing the number of natural gardens. Furthermore, examining the neurological and emotional effect of water features on nature experience. The methodology of the experiment has both objective data collection (EEG) and subjective data collections (Profile of Mood States Questionnaire (POMS) and The connectedness to nature scale (CNS)). The overall benefit of the research is to redefine urbanization with the insight of neuro-architecture for sustainable living.

Part A

A1	The participants have the right to terminate their participation in the research at any time without any explanation or the participants could be omitted if the researcher finds it necessary.
A2	Participants' decisions not to volunteer or terminate being part of the research will not influence the nature of the ongoing relationship they may have with the researchers, the involved faculty members, and the nature of their relationship with Bilkent University either now, or in the future.
A3	No personal information will be released at any stage of this research and all the personal data will be held in confidence by the researcher.
A4	Participants should terminate their participation in case of experience any discomfort with the Emotiv Insight device.
A5	The information participants supply, which are directly related to the research, may be published for academic purposes. However, the participants will not be identified and the personal results will remain confidential.
A6	Participants will be chosen from people who have no mental, physical, or neurological health disorders.

Part B – Signatures

B1 The Participant

I am ______

I have understood the nature of this project and wish to participate. My signatue below indicates my consent.

Signature: **Date:**

B2 The Researcher

I am **Fulya Tolunay**

I explained the aim, the method and the expected benefits of this research to the participant and I admit to preserve the confidentiality of given infomation by the participant and the results of the research.

Signature: ______ **Date:** ______

19/01/22

Bilkent University Faculty of Art, Design and Architecture

Department of Interior Architecture and Environmental Design

The Neurological and Emotional Effects of Human and Nature Interaction:

Walking in Natural Landscapes and Landscape Gardens and Analyses of

Changing Brainwaves in Alpha and Beta Band

Master's Thesis Study by FulyaTolunay

Supervisor: Assoc. Prof. Dr. Yasemin Afacan

Consent form:

Brief description of the study:

The experiment will be conducted in a real environment. The experiment has two setting areas, natural landscape(METU forest area) and landscape garden(ParkOran residential area). Each set is divided into water features and without water features. There are four groups that have 30 participants and the total participant number is 120. The participant will walk for approximately 25 mins. Before and after walking EEG Raw Data with a collection of the Emotiv insight device will be compared. The device is easy to use, easy to wear, and can collect data with our wireless. Each participant wears the device for approximately 6 mins. Moreover, the experiment has written surveys Profile of Mood States Questionnaire (POMS)(both before and after walking) and The connectedness to nature scale (CNS)(only before walking). The final step of the experiment is to give the written demographic form which also includes participant comfort level during the experiment.

Notes:

You will be provided with all necessary information before the study and after the study in debriefing.

You will be given instructions to fit the Emotiv Insight to your head properly.

You will be given instructions about walking the road in this experiment.

Participants' name and signature: Date:

19/01/22

B. CNS SURVEY

C. POMS SURVEY

Duygudurumları Profili (DP)
Aşağıda insanların sahip oldukları duygu ya da hisleri tanımlayan 58 kelimelik bir liste yer almaktadır. Lütfen bunların her birini dikkatle okuyunuz. Daha sonra, bu günde dâhil olmak üzere geçtiğimiz hafta içinde sizin bu duyguları ne derecede hissediyor olduğunuzu tanımlayan en uygun yanıtı işaretleyiniz.
Her bir numara şu anlama gelmektedir: **0=Asla 1=Çok az 2=Orta derecede 3=Oldukça fazla 4=Aşırı**

Gergin	0	1	2	3	4	Yalnız	0	1	2	3	4
Öfkeli	0	1	2	3	4	Zavallı	0	1	2	3	4
Yıpranmış	0	1	2	3	4	Sersem	0	1	2	3	4
Mutsuz	0	1	2	3	4	Neşe saçan	0	1	2	3	4
Hayat dolu	0	1	2	3	4	Acı duyan	0	1	2	3	4
Şaşkın	0	1	2	3	4	Tükenmiş	0	1	2	3	4
Yaptıklarına üzgün	0	1	2	3	4	Sıkıntılı	0	1	2	3	4
Keyifsiz	0	1	2	3	4	Kavgacı	0	1	2	3	4
Olanlara kaygısız	0	1	2	3	4	Kasvetli	0	1	2	3	4
Hırçın	0	1	2	3	4	Çaresiz	0	1	2	3	4
Mahzun	0	1	2	3	4	Tembel	0	1	2	3	4
Aktif	0	1	2	3	4	İsyankar	0	1	2	3	4
Sabırsız	0	1	2	3	4	Yardımsız	0	1	2	3	4
Suratı asık	0	1	2	3	4	Bezgin	0	1	2	3	4
Hüzünlü	0	1	2	3	4	Şaşırmış	0	1	2	3	4
Çalışkan	0	1	2	3	4	Tetikte	0	1	2	3	4
Panik yapan	0	1	2	3	4	Aldatılmış	0	1	2	3	4
Umutsuz	0	1	2	3	4	Kızgın	0	1	2	3	4
Rahat	0	1	2	3	4	Becerikli	0	1	2	3	4
Bir şeye değmeyen	0	1	2	3	4	Enerji dolu	0	1	2	3	4
Kinci	0	1	2	3	4	Aksi huylu	0	1	2	3	4
Huzursuz	0	1	2	3	4	Değersiz	0	1	2	3	4
Hareketsiz duramayan	0	1	2	3	4	Unutkan	0	1	2	3	4
Konsantre olamama	0	1	2	3	4	Dikkatsiz	0	1	2	3	4
Yorgun	0	1	2	3	4	Çok korkmuş	0	1	2	3	4
Usanmış	0	1	2	3	4	Suçlu	0	1	2	3	4
Cesaretsiz	0	1	2	3	4	Dinç	0	1	2	3	4
Gücenmiş	0	1	2	3	4	Herşeyle ilgili şüpheci	0	1	2	3	4
Sinirli	0	1	2	3	4	Ne yapacağını bilemeyen	0	1	2	3	4

D. EXPERIENCE SURVEY

Bilgi Formu

Demografik Bilgiler

Gün içinde en çok vakit geçirdiğiniz binaya yakın yeşil alan var mı?

Evet ◯ Hayır ◯

Varsa pencereden bu alanı görebiliyor musunuz?

Evet ◯ Hayır ◯

Park veya doğal yeşil alanlarda yürüyüş yapma alışkanlığınız var mı?

Evet ◯ Hayır ◯

Haftada ortalama ne kadar süreyi yeşil alanlarda geçiriyorsunuz?

0-60dk. ◯ 1-3 saat ◯ 3-5 saat ◯ 6saat üzeri ◯

Şu an hayatınızda ki stress durumunu 1 en az 5 en çok olucak şekilde numaralandırabilir misiniz?

1 ◯ 2 ◯ 3 ◯ 4 ◯

Deney Bilgileri

Deney sırasında rahat hissedemedim,

Evet ◯ Hayır ◯

Deney sırasında ki hava durumundan rahattım

Evet ◯ Hayır ◯

Deneyde ki yürüşüşten keyif aldım.

Evet ◯ Hayır ◯

Emotiv cihazı takılıyken rahat hissettim.

Evet ◯ Hayır ◯

Rahatsız olmanıza sebep olan durumlar varsa kısaca açıklayabilir misiniz?

....

....

..

Deney hakkında genel öneri veya eleştirileriniz?

....

....

..

....

Katılımız ve katkılarınız için teşekkür ederim :)

..