

Optimization of Indoor Spaces According to the Biophilic Design Criteria by Evidences from Human Body Reactions

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by

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I, Ahenk Karcı, declare that this thesis titled Optimization of Indoor Spaces According to the Biophilic Design Criteria by Evidences from Human Body Reactions and the work presented in it are my own. I confirm that:

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Date: 20.01.2025

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Abstract

After the Industrial Revolution, urbanization has accelerated all over the world, and individuals' ties with nature have gradually weakened with the transformation of working life into an office-centered order. This has had a negative impact on physical and mental health, resulting in increased stress levels, distraction and poor quality of life. Biophilic design is an approach that aims to strengthen individuals' ties with nature and create healthier and more productive working environments. This study examines the integration of biophilic design into office environments and its effects on the physical and mental health of employees.

The research was conducted in two main stages. In the first phase, the definition of biophilic design elements and how these elements can be effectively applied in office environments were analyzed. In the second stage, the physical health indicators of employees in biophilic and non-biophilic virtual office environments were evaluated and compared with the help of EEG data and psychometric tests.

The results of the study revealed that biophilic design reduces employees' stress levels, increases their attention span, improves quality of life and supports overall productivity. In addition, biophilic design was found to have varying effects across demographic differences, with different responses observed especially between younger and older groups. The findings of the study suggest that biophilic design is an important tool for both individual health and organizational productivity.

Keywords: Biophilic Design, Office Design, EEG analysis, Well-being, VR technology



İnsan Beden Tepkilerinden Elde Edilen Kanıtlara Dayalı Olarak Biyofilik Tasarım Kriterlerine Göre İç Mekânların Optimize Edilmesi

Öz

Endüstri Devrimi sonrası kentleşme tüm dünyada hız kazanmış, çalışma yaşamının ofis merkezli bir düzene dönüşmesiyle bireylerin doğayla bağları giderek zayıflamıştır. Bu durum, fiziksel ve zihinsel sağlık üzerinde olumsuz etkiler yaratırken, çalışanların stres seviyelerinde artış, dikkat dağınıklığı ve düşük yaşam kalitesi gibi sonuçlara neden olmuştur. Biyofilik tasarım, bireylerin doğayla bağlarını güçlendirmeyi ve bu bağlamda daha sağlıklı ve üretken çalışma ortamları oluşturmayı hedefleyen bir yaklaşımdır. Bu çalışmada biyofilik tasarımın ofis ortamlarına entegrasyonu ve çalışanların fiziksel ve zihinsel sağlıkları üzerindeki etkileri incelenmiştir.

Araştırma iki ana aşamada gerçekleştirilmiştir. İlk aşamada, biyofilik tasarım unsurlarının tanımlanması ve bu unsurların ofis ortamlarında etkili bir şekilde nasıl uygulanabileceği analiz edilmiştir. İkinci aşamada, biyofilik ve biyofilik olmayan sanal ofis ortamlarında çalışanların fiziksel sağlık göstergeleri, EEG verileri ve psikometrik testler yardımıyla değerlendirilmiştir ve karşılaştırılmıştır.

Araştırma sonuçları, biyofilik tasarımın çalışanların stres seviyelerini azaltarak dikkat sürelerini artırdığını, yaşam kalitesini iyileştirdiğini ve genel üretkenliği desteklediğini ortaya koymuştur. Ayrıca biyofilik tasarımın demografik farklılıklar doğrultusunda

değişen etkileri olduğu belirlenmiş, özellikle genç ve yaşlı gruplar arasında farklı tepkiler gözlemlenmiştir. Çalışmanın bulguları, biyofilik tasarımın hem bireysel sağlık hem de kurumsal verimlilik açısından önemli bir araç olduğunu göstermektedir.

Anahtar Kelimeler: Biyofilik Tasarım, Ofis Tasarımı, EEG analizi, İyi olma hali, VR teknolojisi



Dedicated to my mother and father, with endless love and gratitude...



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List of Abbreviations

ApEn	Approximate Entropy
CD	Correlation Dimension
HE	Hurst Exponent
HFD	Higuchi Fractal Dimension
LLE	Largest Lyapunov Exponent
PTP	Peak to Peak
RMS	Root Mean Square
STAI	State Anxiety Inventory
TMMOB	Union of Turkish Engineers and Architects
TPD	Turkish Psychologists Association
VR	Virtual Reality

1 Inroduction

Currently, the majority of people spend most of their time indoors, especially in office environments, which has serious impacts on the physical and mental health of individuals. Office workers face negative consequences such as stress, distraction and low levels of well-being due to their disconnection from nature (Vimalanathan & Ramesh Babu, 2014). The effects of working conditions on human health are closely related to the changes brought about by urbanization and the industrial revolution in the historical process (Schultz, 2002).

From a historical perspective, human-nature interaction has led to radical changes in the shaping of spaces and the lifestyles of individuals. With the agricultural revolution, hunter-gatherer communities abandoned nomadic life and settled down, establishing the first settlements in human history (S. Kellert & Calabrese, 2015). This process gained momentum with the industrial revolution and migration from rural to urban areas led to the emergence of centralized production mechanisms. The industrial revolution laid the foundation for today's crowded cities and office-based working order. This change has led to individuals moving away from nature and breaking their ties with nature in modern working life (Demirkol & Önaç, 2021).

The majority of today's offices are designed to be disconnected from nature, which has various negative effects on the physical and mental health of employees. Scientific research clearly demonstrates that disconnection from nature leads to increased stress levels, reduced attention spans and lower overall well-being. Such isolated work environments encourage sedentary lifestyles, leading to physical health problems such as obesity and heart disease, while also negatively affecting workers' mental resilience. Lacking the healing effects of nature, these environments increase stress levels, make it difficult to focus and reduce employee productivity (Awada et al., 2023; Zhang et al., 2023)

Biophilic design is a design approach that aims to reconnect people with nature. The term “biophilia” means “love of nature” and biophilic design aims to create spaces that fulfill human nature's need to be close to nature. By integrating natural elements and

processes into living spaces, this design approach creates positive impacts on the health, well-being and productivity of individuals. Especially for individuals who spend long periods of time indoors, biophilic design seeks to support their physical and mental well-being by strengthening their connection with nature (S. R. Kellert et al., 2008).

The basic principles of biophilic design include the use of natural light, vegetation, water elements, natural materials and organic forms. In addition, natural ventilation, a strong visual connection with the outdoors, and the incorporation of natural landscapes into spaces are also important components of this design approach (Ryan et al., 2014). Biophilic design is not only an aesthetic approach, but also a method of enhancing well-being and productivity based on scientific studies. Integrating natural elements into spaces reduces people's stress levels, increases their attention and focus span, and generally improves their quality of life.

The application of biophilic design, especially in offices and workplaces, has a significant impact on increasing employee productivity and satisfaction. Offices with natural light, spaces with indoor plants or structures with a direct connection to the outdoors contribute to making employees less stressed, more motivated and more productive (Elantary, 2024). At the same time, biophilic design is in line with sustainability principles and offers solutions that support energy saving and ecological balance (Gillis & Gatersleben, 2015).

Existing studies examining the effects of biophilic design in office environments generally use traditional research approaches such as literature reviews, surveys and qualitative methods. Yildirim et al. (2024) reviewed the literature obtained from Scopus and Web of Science databases in accordance with PRISMA guidelines and evaluated the psychological, physiological and cognitive effects of biophilic design using the Analytic Hierarchy Process (AHP) method. The study revealed that greenery, nature views, and daylight provide the highest benefits from biophilic design elements, while natural materials have a lower effect size. Hähn, Essah, and Blanusa (2020) evaluated the effects of plants on creativity and productivity by giving live plants to office workers through a survey method and emphasized the limited effect of individual contact. However, it was observed that removing plants from the environment created negative effects. Gray and Birrell (2014) evaluated the effects of

open spaces, natural lighting and sustainable materials through observations and interviews and found that biophilic design reduces stress levels and increases collaboration. Aduwo et al. (2021) examined the effects of biophilic design on productivity in office buildings in Lagos using a survey method, but emphasized that current practices are insufficient and it is important to integrate these elements at the design stage.

While these studies have demonstrated the benefits of biophilic design, the methods used have generally been limited to generic approaches. Therefore, studies with a different methodology from the existing research can make important contributions to this field.

This study aims to examine the integration of biophilic design elements into office environments and evaluate the effects of these elements on the physical and mental health of employees. Based on the biophilic design components identified through literature reviews and expert opinions, the study aims to provide guiding findings in practice. In the first stage, the basic components of biophilic design are defined and how elements such as natural light, vegetation, water elements, natural materials and organic forms can be effectively implemented in office environments are discussed. The main focus of the research is to empirically evaluate the effects of biophilically designed office spaces on employees' physical health (e.g. physiological measurements such as pulse rate and blood pressure) and mental processes (cognitive performance, attention duration and EEG data).

The main hypothesis of the study is that biophilic design positively affects individuals' physiological and psychological responses by enhancing human-nature interaction, thereby reducing stress levels and increasing cognitive performance. This hypothesis is based on literature findings that biophilic design elements will benefit both the physical and mental health of employees.

In this context, the study is shaped around the following research questions:

1. Which biophilic design elements are critical to office design?
2. How do biophilic and non-biophilic office environments affect the physical health of employees?

3. How do biophilic design elements affect employees' mental processes and cognitive performance?
4. How do demographic characteristics affect responses to biophilic design

In the first phase of the research, the basic components of biophilic design were defined and the importance of these elements in office environments was determined by experts.

In the second phase, the physical health impacts of an office environment containing the biophilic elements identified in the first phase and an office environment without any biophilic elements were compared using virtual reality glasses.

Physical health indicators, especially pulse and blood pressure measurements, were analyzed and changes in stress levels were discussed. In the third stage, the effects of biophilic design elements on employees' mental processes and cognitive performance were evaluated with the help of EEG data and psychometric tests. In this stage, the potential of office spaces with biophilic design to provide mental relaxation by increasing the attention span of employees was analyzed in detail.

Finally, the effects of biophilic design elements on different demographic groups were analyzed. The differences of variables such as age and gender on the responses to biophilic design elements are discussed and how the effects of these elements differ are evaluated.

Figure 1.1 shows the overall structure of the thesis and provides a comprehensive summary of the main chapters such as literature review, methodology and findings.

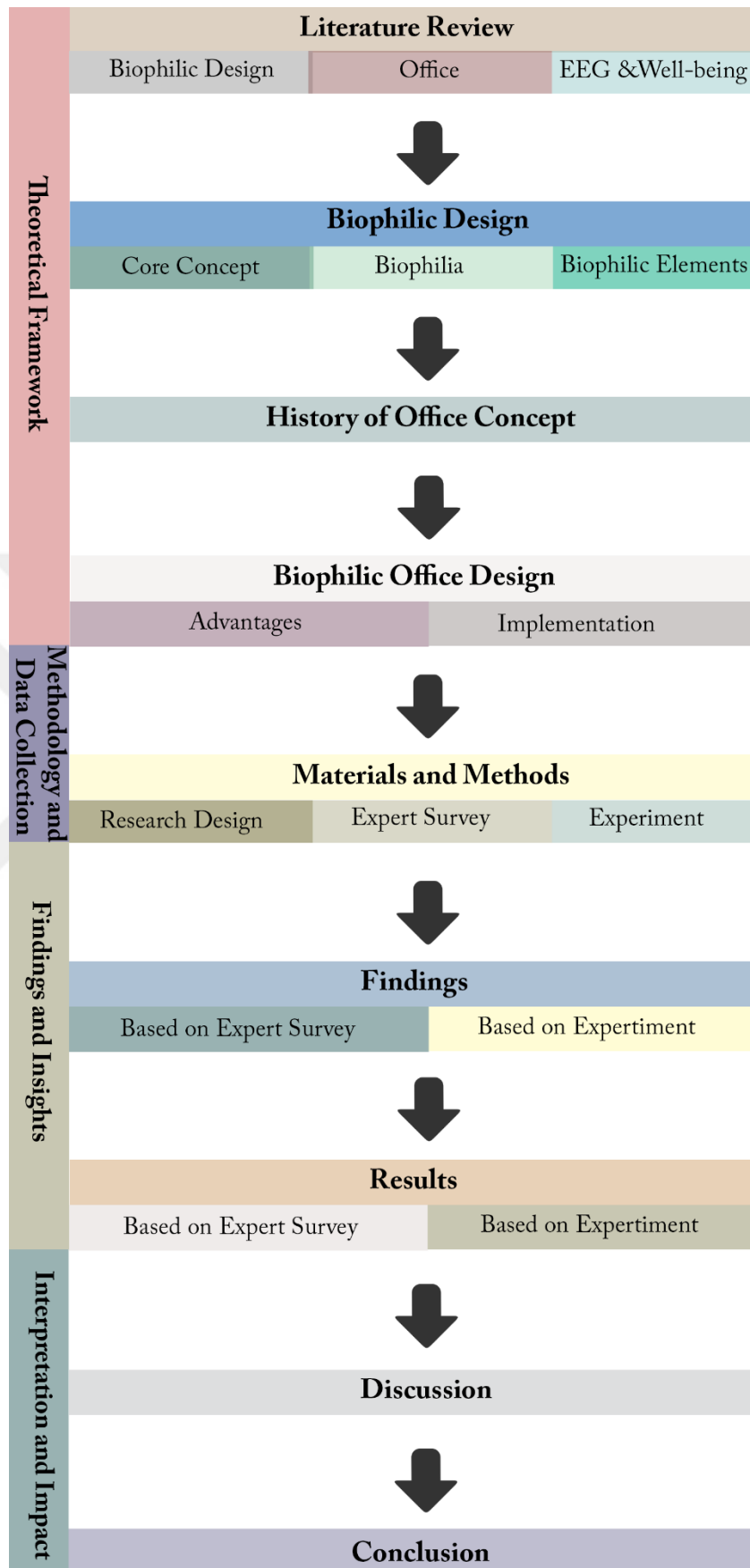


Figure 1.1 General structure of the thesis

The overall structure of the thesis follows a systematic flow, as presented in Figure 1.1. The study started with a literature review and comprehensively addressed issues affecting employee well-being such as biophilic design, office design and EEG. Once this basic framework is established, the conceptual infrastructure and key elements of biophilic design are defined through elements such as natural light, plants, water elements and natural materials. Afterwards, the concept of office and its historical development are analyzed and the place of biophilic design in this context is evaluated.

The research focuses on biophilic office design by detailing the advantages and applicability of biophilic design. In the methodology section, the details of the research design, expert surveys and experimental studies are presented and how these studies were carried out are explained. In the findings section, the data obtained from the expert surveys and experimental studies are analyzed and analytical results are presented. In the Results section, these findings are interpreted and meaningful inferences are made. In the discussion section, the findings were compared and evaluated with the existing information in the literature. The study is concluded with general conclusions, the contribution of the research to the literature and recommendations.

In summary, this study demonstrates with empirical data that biophilic design is an effective tool for creating a productive and healthy working environment in modern workplaces. The study has comprehensively addressed the theoretical and practical dimensions of biophilic design by providing both empirical data and practical contributions to the academic literature. The effects of biophilic design on improving employee well-being, reducing stress levels and supporting productivity are evidenced by empirical data. In addition, the most important elements of biophilic design are identified through expert opinions. In addition, it offers biophilic design strategies for the global business world, guiding the improvement of work environments in a more sustainable, people-oriented and innovative way. This study shows that biophilic design can be an effective tool in corporate strategies that prioritize employee health and well-being as well as its visual effects.

2 Previous Researches

Within the scope of the thesis, previous scientific studies on the subject have been addressed through a comprehensive literature review. This review is presented under four main categories: biophilic design, office design, well-being in the office environment and the relationship between EEG and well-being. Under each category, the general trends of the existing literature and current research are summarized in detail.

2.1 Studies Related to Biophilic Design

The study develops this theoretical framework through a meta-analysis of experimental studies on the emotional effects of exposure to natural and urban environments, identifying 49 relevant studies with a total of 3,201 participants. The most important findings show that exposure to natural environments has a moderate to large effect on enhancing positive emotional impact and reducing negative impact. This finding supports the anticipated emotional dimension of the biophilia hypothesis and lends credibility to biophilic design theory (Gaekwad et al., 2022).

Peters & D’Penna, (2020) 's study investigates the effects of biophilic design in university environments. The literature review highlights key issues in the multidisciplinary research on the impact of the built environment in university student housing, including emotional stress, happiness, arousal, cognitive function, social support, a sense of belonging, study spaces, lighting, and ventilation. The semi-structured literature review results identify, analyze, and categorize related studies examining natural landscapes, nature imagery, natural colors, natural materials, auditory and olfactory aspects of nature, nature imagery with water, indoor plants, campus landscapes, study spaces, local materials and style, daylight access, and thermal and environmental comfort. Consequently, they propose designs to integrate biophilic design into university environments.

This study examines the effects of biophilic design elements in hospital environments. Conducted as a literature review, it aims to establish a standardized biophilic design framework to improve future design in this context by examining the experiences of

hospital users (patients and staff). The most important findings of the study are identified as outpatients (fresh air, light-daylight, thermal comfort, inviting and relaxing features), inpatients (feeling relaxed and comfortable, shelter from the view, safety and protection, light-daylight, view), and staff (privacy-shelter, silence) (Tekin et al., 2022).

The human-nature connection, as one of the elements of biophilic design, has the potential to increase the benefits of sustainable buildings, both in terms of energy-saving practices and tangible improvements in occupant satisfaction, health, and well-being. This study aims to demonstrate the potential of the human-nature connection through the adoption of biophilic design principles to improve the performance of a residential building. A terrace house in Sydney, NSW is selected as a case study for this purpose, and the designed scenarios in terms of improved lighting, thermal comfort, and energy consumption are computer simulated. According to the results, building performance improves in terms of lighting, thermal comfort, and reduced energy consumption. In addition, the human-nature connection in the building increases (Nitu et al., 2022).

In a post-COVID-19 pandemic survey on hotel preferences, participants responded to questions regarding the specific impacts of COVID-19, the advantages of nature, and their accommodation preferences. The primary findings indicate that the COVID-19 burden elevates participants' stress levels, subsequently increasing the risk of depression. Additionally, perceived stress and the benefits of nature significantly affect tourists' preferences for exposure to nature and their inclination toward hotels with biophilic characteristics (Khozaei et al., 2022).

The research examines the notions of health, sustainability, and resilience in urban environments within the framework of biophilic design. Consequently, the research is centered on the subsequent inquiries: "What shared variables and components are present when endeavoring to establish a sustainable, healthy, and resilient environment?" and "In what manner can these components be associated with biophilic design patterns to devise solutions that enhance individuals' health and well-being?" Through the application of content analysis, the research discerns 19 intersecting concepts, which encompass security, crime risk, water, environment, green spaces, food, housing, transportation, education, planning, economy, pollution,

politics, society, and governance. As per the findings, 16 of these concepts are intricately linked to biophilic design, and biophilic design possesses the potential to offer solutions to the challenges inherent in the paradigm of healthy, sustainable, and resilient cities (Cacique & Ou, 2022).

Mollazadeh and Zhu, (2021) examine the application of biophilic design elements within Virtual Reality (VR) environments. Their literature review reveals that VR is capable of enhancing key aspects of biophilic design. These aspects include the integration of various biophilic patterns, provision of multisensory stimuli, simulation of stress-inducing scenarios, facilitation of adequate exposure to biophilic elements, and assessment of physiological responses to natural settings. Despite these benefits, the user experience in virtual biophilic environments can be influenced by several factors, such as the different dimensions of VR experiences, individual user characteristics, VR sickness, navigation challenges, and the limitations of VR sensory inputs. Furthermore, the authors highlight the scarcity of biophilic design studies utilizing VR technology.

The study aims to identify strategies to advance the integration of biophilic design in Australian buildings. In this context, semi-structured interviews are conducted with 24 architects and building sustainability consultants. The data is analyzed using both manual and natural language processing techniques. The study puts forward nine strategies to accelerate the adoption of biophilic design, including making biophilic design a core subject in architectural and building sustainability education, mandating minimum biophilic specifications in building codes and regulations, demonstrating the business benefits of biophilic design to clients, making biophilic design a core value in design organizations, and disseminating research and knowledge on the cost-effective application of native vegetation. The study proposes a comprehensive framework for integrating nature into buildings, highlighting macro and micro opportunities and their interactions. The findings provide practical strategies for stakeholders such as governments, design organizations, and professionals to promote the adoption of biophilic design in Australia (Sadick & Kamardeen, 2024).

This study explores the influence of biophilic design on healthcare environments, with a particular focus on its impact on mental health in children's hospitals. The findings indicate that incorporating biophilic elements into the design of children's hospitals

significantly enhances the mental well-being of patients, thereby facilitating their recovery process (Sabaa et al., 2022).

In the study, biophilic design practices are applied to the train station, an urban area, through virtual reality. 352 participants evaluate three different levels of greenery with virtual reality. Statistically significant results between the groups include improvements in well-being, aesthetics, stress reduction, perception of trust, psychological noise reduction, and perception of identity. It is also found that women prefer higher levels of greenery than men (Kalla et al., 2024).

2.2 Studies Related to Office Design

This study explores the effects of natural views and daylight from windows on thermal perception, health, and energy efficiency in office spaces. Conducted with 20 participants under three different thermal conditions (17 °C, 20 °C, and 23 °C) in spaces with and without windows, the research measured environmental parameters, physiological responses (arterial oxygen saturation - SpO₂ and heart rate variability), and subjective feedback (thermal perception, emotions). The findings reveal that participants with access to a visual window experienced greater comfort in cooler environments. Additionally, these participants exhibited higher SpO₂ levels, which correlated with a reduction in symptoms of sick building syndrome, and an increase in heart rate variability, indicating reduced stress and fatigue. Although daylighting did not enhance illumination perception, it achieved an 82% energy saving. Visual windows also improved occupants' tolerance to varying thermal conditions, resulting in an energy saving of approximately 1.21°C in Heating, Ventilation, and Air Conditioning adjustments. Overall, the study demonstrates that biophilic design elements such as visual windows significantly enhance thermal comfort, reduce stress and fatigue, and offer substantial energy-saving benefits (Jiang et al., 2022).

In a study of 355 employees working in 5 science parks in Scotland, it is found that there is a linear relationship between employees' use of green space and the opportunity to observe plant species such as trees and shrubs indoors through windows and their level of well-being. This research suggests that workplace green spaces have the potential to contribute to employee well-being and emphasizes the importance of workplace designs that incorporate restorative window views (Gilchrist et al., 2015).

The study measures the impact of electrochromic glazing on the perceived physical and emotional well-being of office workers. Thirty office workers work in two offices with electrochromic glass and two offices with partially covered standard glass. Those who work in the office with electrochromic glass are more satisfied with the daylight conditions and views outside and report less eye fatigue and fewer depressive feelings (Woo et al., 2021).

This study is conducted in five different offices in the Netherlands with the participation of a total of 579 employees. The aim of the study is to investigate the effects of office layouts, orientations, and facade angles on employee satisfaction. In this research, conducted using the survey method, office layouts, orientations, and the desk position parameter are taken into consideration. As a result of the analysis, it is determined that office layouts and desk locations are the determining factors for satisfaction variables. It is concluded that, for optimal satisfaction, cellular office layouts, northwest-oriented workstations, and desk positions 4 meters from the window should be preferred (Kwon & Remøy, 2020).

The study, conducted as a literature review, examines the work, health, and social consequences of knowledge-based work carried out in open-plan offices. A total of 10,242 articles are reviewed, and 31 articles on this topic are selected. The results reveal that working in open-plan workplace designs is associated with many negative outcomes in terms of health, satisfaction, productivity, and social relations. In particular, notable health outcomes include decreased overall health and increased stress. Environmental aspects include noise and distractions, poor privacy, lighting and glare, and poorer temperature control. Most studies report negative impacts on social relationships and interactions. Overall, the findings suggest that open-plan workplace designs can offer financial advantages for managers, but these are offset by negative impacts on workers (James et al., 2021).

The thesis examines the effects on employees of office spaces that include specific play activities or have a more playful design in terms of colors, layout, or furniture. The study includes empirical data collected from a total of four different companies with six employees of different genders, ages, and roles. The most important finding of the research is that such offices have a positive impact on employees. Even if employees are not directly involved in these activities, being in an environment where

activities are encouraged and seeing others having fun has a positive impact on employee well-being (Sardal & Eneberg, 2023).

The study examines the effects of the sound level in an open office environment on employees. Using an experimental methodology, the study compares the effects of a typical open office sound environment to a quieter private office sound environment in terms of various objective and subjective measures of well-being and performance in a simulated office setting. The study finds that open office noise does not immediately reduce cognitive task performance compared to a quieter environment. However, it is found to negatively impact mood, emotional facial expressions, and emotional well-being, with physiological indicators of stress such as heart rate and skin conductance showing effects (Sander et al., 2021).

In the study, a prototype of a user-oriented building management system is proposed to improve the energy efficiency of office buildings. This prototype is collaboratively developed, tested, and evaluated over two heating periods in six office buildings and 85 offices in Germany. The results show that such a user-oriented approach can save up to 20% of energy while maintaining or even increasing comfort and work efficiency (Baedeker et al., 2020).

This study investigates ways to enhance natural window ventilation efficiency in an office setting within a humid subtropical climate. Key design parameters, including window type, opening percentage, location, and furniture arrangement, are evaluated across multiple factor levels. The Taguchi method is employed to provide quantitative insights using the L27 orthogonal array, identifying and ranking the effects of these variables on objectives such as air exchange rate and ventilation efficiency. Signal-to-noise ratio calculations confirm the significance of the evaluated parameters, with the percentage contribution of each parameter assessed through analysis of variance (ANOVA). Additionally, gray relational analysis (GRA), grounded in gray system theory, is utilized to optimize multiple design factors. Validation tests indicate that the optimal configuration enhances room air exchange rate and air exchange efficiency by 0.00293% and 1.09%, respectively (X. Yin et al., 2023).

This study, conducted in Abuja, Nigeria, aims to integrate the principles of green architecture into the design of an office building to reduce artificial energy

consumption for optimal building performance. The study involves a data collection process in which a total of 350 questionnaires are administered to experts in the building industry and users of office buildings. The findings reveal a general agreement among respondents that energy use and activities in office buildings in Abuja increase fuel expenditure. It also shows that respondents agree on the need for implementing green architecture policies in Nigeria. The study states that the office environment is favorable in terms of natural lighting and natural ventilation. In conclusion, it is determined that green architecture principles are critical to improving energy consumption in the design of office buildings (Idowu & Abdulrahman, 2023).

2.3 Studies Related to Office Design and Wellbeing

The study systematically examines the current state of research on the restorative benefits of biophilic design in workplaces. In accordance with PRISMA guidelines, 74 peer-reviewed articles are selected from a literature search using Scopus and Web of Science databases. Analytic Hierarchy Process (AHP) analysis reveals that biophilic design can provide significant psychological, physiological, and cognitive benefits in the workplace, with varying effect sizes observed across four outcome measures for each design pattern. The results of the study show that greenery, nature views, daylight, and visual comfort are associated with the largest effect sizes, while nature simulations, multisensory experiences, water features, and natural materials have smaller effect sizes. Furthermore, some biophilic design patterns have almost no impact on the outcome measures, highlighting the diversity of positive effects that biophilic design can have in workplace environments (Yildirim et al., 2024).

Hähn, Essah, and Blanusa (2020) investigate the effects of plant presence in office spaces on health, happiness, creativity, productivity, and stress. In the study, 40 participants are given 2 live potted plants to be planted. Additionally, live plants are placed in common break areas. The satisfaction level of office workers with the plants is evaluated through survey questions. As a result of the study, the process of planting live plants shows no effect on the participants. However, participants' creativity and productivity increase in areas with plant presence, while the removal of plants has the opposite effect. Participants' contact with plants during breaks does not show a significant positive effect.

Gray and Birrell (2014) examine the effects of biophilic design elements such as open space, natural lighting, recycled materials, and natural materials on office workers. The materials of the study consist of interviews with participants, pictures, and camera footage obtained from the observation study. The study lasts a total of 6 months. The plant species selected for the study include *Spathiphyllum spp.*, *Sansevieria spp.*, *Zamioculcas zamiifolia*, *Aspidistra spp.*, and *Ctenanthe setosa*. Twenty-three randomly selected participants take part in the study, including 17 employees, 6 spouses, and 3 children. In the study, vertical gardens are constructed from pallets (construction site waste material), a sustainable material, by establishing a mentor-apprentice relationship, and the selected plant species are planted. Three weeks after the activity, 15-minute interviews are conducted with 6 of the participants to determine the effect of the activity. According to the results obtained from the interviews, biophilic design elements are found to increase the quality of life and productivity of employees and reduce stress levels. Additionally, the activity is found to make positive contributions to cooperation and social relations among employees.

Sanchez, Ikaga, and Sanchez (2018) conduct a pilot experiment to experimentally measure the effects of biophilic design elements on productivity and well-being enhancement. User perceptions are assessed using the NASA TLX, subjective workplace performance evaluations, and the Jikoko-sho questionnaire. To provide an objective assessment, the study utilizes three experimental groups—plants only, daylight only, and a combination of both—alongside a control group. The physical and physiological parameters of participants are measured, including heart rate, sympathetic activity, salivary amylase activity, blood pressure, tympanic temperature, and activity level. Additionally, daily measurements are taken for temperature, relative humidity, CO₂ levels, and light intensity during the experiment. The experiment involves a total of eight male students ($18.5 < \text{Body Mass Index (kg/m}^2) < 25.0$) who do not smoke. Participants perform a total of six tasks simulating office work—three tasks in the morning and three in the afternoon—including text writing and mind mapping. Initially, participants respond to a survey regarding activities from the previous day, followed by physiological measurements, surveys, and two simulated tasks, each lasting 25 minutes. These tasks are repeated for each combination of light and plant presence as well as for the control group. To mitigate the effect of task completion time on performance, an additional task is included but its results are

excluded from analysis. Participants are given a 15-minute rest period between tasks in an area with plant presence and natural sunlight. In this space, participants are instructed to either walk or sit at a desk. Those who consumed alcohol the previous night or skipped breakfast are excluded from the study. Since it is assumed that changes in hunger and fatigue levels could affect the results, the experiments are conducted twice daily, in the morning and afternoon. The study finds a positive relationship between plant presence and satisfaction with the thermal environment. A negative correlation is observed between satisfaction with plant presence and daylight and subjective perceptions of fatigue. Biophilic design appears to positively influence subjective perceptions of thermal comfort, and the use of natural light in the workplace is likely to reduce feelings of fatigue, particularly in the afternoon, where a more significant relationship between daylight and fatigue perception is observed. Although plant presence impacts subjective perceptions of drowsiness, physiological tests indicate that daylight has an objective effect on reducing drowsiness. Salivary amylase results suggest that plant presence has a stress-reducing effect.

Yin et al. (2020) explore the impact of biophilic design on stress levels in office environments through a study involving 100 participants using Virtual Reality (VR). Participants were exposed to a non-biophilic office and three different biophilic offices, which incorporated elements such as daylight, plant presence, and a combination of both, after completing stressful tasks. The experimental study measured physiological indicators of stress, including heart rate variability, heart rate, skin conductance level, and blood pressure, using bio-monitoring sensors. Additionally, participants' anxiety levels were assessed using the State-Trait Anxiety Inventory test. The findings indicate that offices with biophilic elements significantly reduce participants' stress and anxiety levels compared to non-biophilic offices. Among the three biophilic environments, the office incorporating both daylight and plant presence demonstrated the most substantial restorative effects. Furthermore, the study highlights that experiencing nature through VR can positively influence stress reduction and provide therapeutic benefits.

The study is conducted in Lagos, Nigeria, with the participation of employees from selected office buildings that incorporate biophilic design elements. The aim of the study is to determine the effects of biophilic design elements on user productivity. The methodology of the study is a questionnaire survey. Participants are selected by the

stratified random sampling method. A total of 120 questionnaires are distributed, with 58 participants responding. The study finds that biophilic design elements significantly impact employee productivity. However, the implementation of these elements in the selected office buildings is insufficient. For the successful application of biophilic design elements, integrating them during the design phase is of great importance rather than adding them to architectural designs later. (Aduwo et al., 2021).

In the study, Virtual Reality (VR) is used to pre-evaluate the potential of biophilic design interventions in interior spaces. The study compares three different office layouts (Indoor Green, Outdoor Green, and Non-Biophilic) and three different acoustic scenarios (Office, Office + Traffic, and Office + Nature). A total of 198 participants complete three cognitive tasks for each acoustic condition and fill out a questionnaire. The findings of the study indicate that VR is an effective tool for assessing the potential of biophilic design interventions. Results from the cognitive tests reveal that an auditory-visual connection with nature can positively affect working memory, task-switching performance, and inhibition. The acoustic factor shows a higher improvement effect compared to the visual factor, with an improvement rate between 23% and 71%, while the visual factor shows an improvement between 12% and 39%. Furthermore, natural sound in the Indoor Green condition is found to be the most supportive visual and acoustic condition, while traffic in the non-biophilic environment is the most disruptive condition. (Latini et al., 2024).

A survey of employees at the Genzyme headquarters in Massachusetts assesses how the new building, designed with biophilic design elements, impacts their work experience. The majority of employees surveyed state that the new building with biophilic design elements helps them feel more productive, happy, and connected. Approximately 72% of respondents report feeling more alert and productive, 88% say that direct views and access to interior gardens increase their sense of well-being, 75% mention that the building's open glass design enhances their connection with colleagues, and 92% indicate that the building's connection to nature boosts their sense of pride in Genzyme. These results demonstrate that biophilic design positively influences employee satisfaction and performance in the workplace. (Lerner & Stopka, 2016).

Lan et al., (2009) evaluate the impact of indoor quality on employee productivity using a neurobehavioral approach. In this context, four neurobehavioral functions—perception, learning and memory, thinking, and execution—are measured using nine representative psychometric tests. Additionally, the effect of room temperature on the performance of neurobehavioral tests is investigated in a laboratory environment. Four different temperatures (19°C, 24°C, 27°C, and 32°C) are examined based on thermal perception from cold to hot. Signal detection theory is used to analyze response bias. The study shows that room temperature affects task performance in various ways, depending on the type of task. Furthermore, it is found that motivated individuals are able to exhibit high performance for short periods under challenging (hot or cold) environmental conditions.

Tahoun, (2019) 's research investigates the awareness of the effects of biophilic design on human health and its application areas in the construction industry in Egypt. In this context, a questionnaire survey on the benefits and experience of biophilic design is prepared and administered to a total of 70 people, including architecture students, developers, government officials, project managers, and academics in the construction field. According to the survey results, academics are the most informed group about biophilic design, while other respondents have limited knowledge. Additionally, other expert groups find green roof applications especially important. It is determined that other groups need to be more aware of the implementation of biophilic design.

2.4 Studies Related to EEG (Electroencephalography) and Wellbeing

The study investigates the effects of different types of music on stress responses. In the study, 9 female subjects are used, selected according to certain criteria. The subjects are non-menstruating, non-psychologically ill, right-handed, have a similar body mass index, and are 22 years old. None of them have any musical training. The same criteria are used for the control group. Subjects do not consume alcohol, caffeine, medication, or smoke on the day of the experiment. The experiment is conducted over 4 days and repeated each day using different types of music: relaxing music, rap music, and ASMR-triggering music. During the experiment, subjects' blood pressure and pulse rate are measured, and their EEGs are monitored throughout. The most important

findings of the study show that ASMR-triggering music and relaxing music reduce stress equally, significantly affecting stress reduction over time. However, rap music is found to delay stress reduction (Paszkiel et al., 2020).

This study explores the impact of plant density (Pd) and integrated sound environment (IsoA) on human neural emotions. Pd is examined as a visual variable at three levels: high, medium, and low. IsoA is analyzed at four levels: low-decibel natural and low-decibel artificial sounds, low-decibel natural and high-decibel artificial sounds, high-decibel natural and low-decibel artificial sounds, and high-decibel natural and high-decibel artificial sounds. A total of 360 university students were randomly assigned to 12 different groups (N=30). Each group underwent a 5-minute high-pressure learning task, followed by a 5-minute audio-visual recovery period. During the pre-test and post-test phases, neural emotion markers such as excitement, focus, interest, relaxation, engagement, and stress were measured using the Emotiv EPOC X device. The findings demonstrate that both Pd and IsoA significantly influence human neural emotions. Higher levels of artificial sound positively affected excitement in medium and high IsoA conditions. Additionally, greater plant density led to more pronounced excitatory neural emotions. The low and high Pd conditions exhibited a higher degree of visual continuity. A negative relationship was observed between attention recovery and stress recovery under the influence of IsoA. Overall, the study concludes that an optimal combination of Pd and IsoA can enhance the health benefits of green spaces and improve the well-being of visitors (Zeng et al., 2021).

The research is conducted on Informal Green Spaces, commonly known as green wastelands, assessing emotional well-being using portable electroencephalography (EEG) devices. Through the EEG Muse headband, the study analyzes the calmness and alertness of 20 participants who visit selected Informal Green Spaces in Warsaw, Poland. The aim of the study is to test the effects of passive recreation in Informal Green Spaces on emotional well-being and to examine the relationship between calmness and alertness states and green space type, landscape type, and Informal Green Space type. The preliminary experiment results show that there are no significant differences in users' emotional states based on the available typologies. However, data analysis suggests a possible relationship between the state of alertness in certain areas and some characteristics. Analyses in a repeated-measurement setup identify significant differences between oscillations in different areas and suggest three

possible sources for lower alertness and increased calmness in certain areas. These sources are identified as the presence of desired human interventions, the absence of unwanted users, and the presence of other desired users (Herman et al., 2021).

The study investigates the role of the built environment of an academic campus in influencing mental renewal and well-being perceptions of students who are constantly at risk of stress and psychological distress. A survey of 429 university students is conducted through a questionnaire to identify activity centers on campus. In these centers, a neuropsychological study is conducted with 22 students using mobile EEG and the Perceived Renewability Scale (PRS) to examine the effect of the built environment on regeneration approach/neglect behavior and perception of the built environment. The study focuses on four important theoretical constructs: Attentional Renewal Theory (ART), Stress Reduction Theory (SRT), Arousal Theory, and Appearance and Refuge Theory. These theories are used to develop combination mechanism-based hypotheses to identify the elements of a mentally resilient campus building-environment. Statistical analyses of the study show that certain environmental elements, such as vegetation, novelty/uncertainty, acoustic ambience, and expansive views, are positively associated with positive approach behaviors and normalized mean alpha brain waves. However, other elements, such as the presence of high building density, may be associated with avoidance behaviors. Greenery and sky have the most positive association with Normalized Alpha, while a negative association is observed for structures. It is noteworthy that a stronger structure density is associated with a weaker level of normalized alpha waves. The study also reveals that natural components such as grass, sky, and filtered and diffused light enhance perceptions of the regenerative properties of an environment (Asim et al., 2023).

Mir et al., (2022) investigate the impact of various types and levels of construction noise on emotions using EEG data. The study involves twenty-three participants who are exposed to different construction noise conditions. Two power spectral analysis methods are employed: the traditional approach and parameterizing the neural power spectrum. Additionally, participants' perceptions of noise-induced annoyance and stress are collected through a questionnaire. The data is analyzed using linear mixed models. Results from the questionnaires indicate that construction noise significantly influences boredom and stress levels. EEG data analysis further reveals that different types and levels of construction noise elicit distinct brain signal responses. Notably,

noise from saws and jackhammers produces the most adverse emotional effects on participants.

The study focuses on the effects of behaviors such as walking and sitting, commonly performed in urban green spaces, on emotional changes. A total of 40 university students participate in the study and are randomly divided into walking and sitting groups. Both groups complete the same 8-minute high-pressure learning task indoors and then engage in an 8-minute recovery activity in a simulated urban green space (such as a bamboo-grass area). Emotiv EPOC+ EEG headphones are used to dynamically measure participants' emotional states (“engagement,” “spontaneity,” “meditation,” “frustration,” “focus,” and “excitement”). The results of the behavior comparison show that the “natural” and “meditation” values of the walking group are higher than those of the sitting group, indicating that walking in urban green spaces is more suitable for stress reduction. The “focus” value of the sitting group is higher than that of the walking group, suggesting that sitting in urban green spaces is better for attention restoration (Lin et al., 2020).

The study examines how light projections designed using biophilic design principles can support well-being in urban environments. Four biophilic projections are designed to trigger positive emotions such as relaxation, and four non-biophilic patterns are used for comparison. All eight designs are tested on five participants using quantitative methods of electroencephalography (EEG) and qualitative surveys with ratings and an adaptation of the Discrete Emotions Questionnaire, including open questions. The EEG results show that 75% of the biophilic patterns evoke a positive emotional response compared to the control group, while 50% of the non-biophilic patterns show an expected negative emotional response compared to the control group. Additionally, the qualitative survey reveals that biophilic patterns produce a 135% more positive outcome than the control group and 417% more positive than non-biophilic patterns (Hill & Triantafyllidis, 2023).

The research aims to evaluate the impact of street design on people's emotional states. The study combines two different methods: (1) a self-assessment method using Self-Assessment Manikin (SAM) images and (2) a neurological method using electroencephalography (EEG). For the EEG method, the single-channel MindWave MW001 headphones manufactured by Neurosky are used. The results of the study

show that curves in streets add an exciting feature, streets with moderate closure have the most desirable size and closure values, and squares and prominent structures increase the enjoyment and stimulation of streets. It is also found that three-dimensional walls cause more satisfaction and arousal than walls with two-dimensional and three-dimensional rhythms. The results suggest that factors such as visual permeability in street design affect people's emotional responses and that technologies like EEG can be used to measure such emotional changes (Paikan et al., 2022).

This study explores the psychological effects of viewing green spaces from high-rise apartment windows. Thirty participants were randomly assigned to two offices on the 21st floor of Jin-Mao Tower, each with either a city view or a green view. The researchers used methods such as electroencephalography, heart rate variability, and skin conductance to measure participants' physiological stress levels. Additionally, the Profile States and Semantic Difference Questionnaire assessed their psychological responses. The results indicate that compared to the cityscape view, observing green spaces from a high-rise window significantly increases alpha wave power in the anterior and posterior lobes, enhances parasympathetic activity, and decreases skin conductance. Participants also reported feeling more “comfortable,” “beautiful,” “attractive,” “relaxed,” and “cheerful,” with a notable improvement in overall mood state (Elsadek et al., 2020).

The study is conducted using the Perceived Novelty Scale (PRS-11) and EEG to assess the effects of indoor plant density on people. A positive relationship is found between increasing indoor plant density and novelty. However, a trend point is observed at a plant density range of 13-24% in indoor environments. In terms of perceived novelty and stress reduction, the optimal indoor plant density is found to be 13-24% (Rhee et al., 2023).

3 Biophilic Design

In this chapter, the fundamentals of biophilic design are examined under two headings: the relationship between humans and nature, the concept of biophilia and biophilic design. In the first section, the relationship between human and nature and the biological foundations of this relationship are discussed. In the second section, provides a definitive overview of the concept of biophilia and the approaches developed by biophilic design based on this foundation.

3.1 The Relationship Between Mankind and Nature

The Earth is thought to have formed approximately 4.6 billion years ago and the first living species are thought to have appeared 3.5 billion years ago. The human race began to evolve 200,000 years ago. The oldest discovered traces of our species are cave paintings dating back about 40,000 years. Humans first started farming 12,000 years ago and the first cities were established 6,000 years ago. One of the 2 important cultural changes that humanity has undergone in this process is the discovery of agriculture and the other is the transition to mass production with the industrial revolution that started 400 years ago (Çorakçı, 2016; S. Kellert & Calabrese, 2015). Figure 3.1 summarizes the processes that have influenced human life.

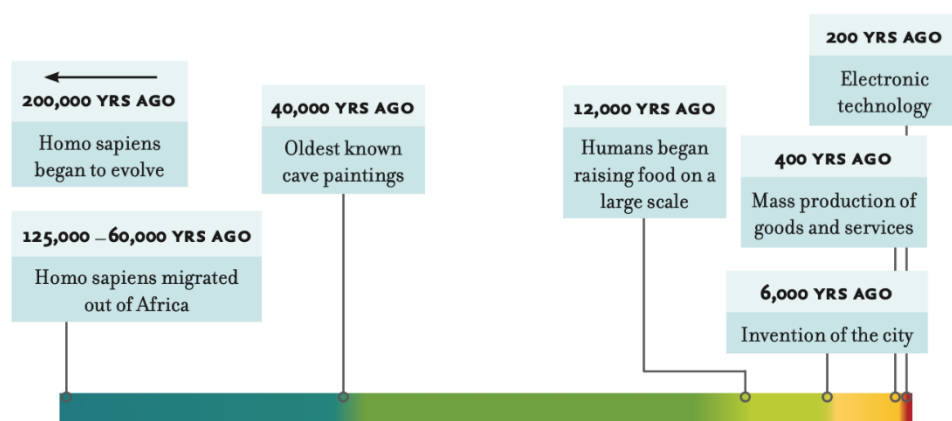


Figure 3.1 Events affecting human beings throughout world history (S. Kellert & Calabrese, 2015)

Turkman (2000) states that the cultural and ecological development of human beings can be analyzed in five stages: early hunter-gatherer, advanced hunter-gatherer, agricultural man, industrial man and world man (Çorakçı, 2016).

In the early hunter-gatherer period, people made various tools by shaping materials found in nature, such as stones and sticks, and made clothing for themselves by using the skins of animals. In this period, people were unable to control the natural conditions and tried to adapt themselves to the conditions of nature by migrating to suitable geographical regions. In the advanced hunter-gatherer period, the discovery and effective use of fire increased people's ability to protect themselves (Atasoy, 2015). Especially in the human groups that lived in these periods, human-nature interaction was in the form of observing the nature that developed as a result of people's concern for sustaining their lives and organizing their lives by making some observations as a result of these findings (Sulak, 2018). When environmental problems are analyzed chronologically, it can be said that in these periods, human beings were content with the opportunities offered by nature, made little effort to change nature, and the healthiest relationship with nature throughout human history belongs to this period (Güney, 2017).

For most of human history, people have had to live their lives depending on the rising and setting of the sun. Solar and climatic conditions have greatly affected people's daily routines. Today, due to the developing technology, living conditions have become easier and people have been able to live their lives without being dependent on these conditions with the help of protection from climatic conditions and artificial light. Although the sun cannot control people's daily routines today, the wavelengths of light whose main source is the sun still affect the chemistry of the human body, circadian rhythms, pituitary gland, endocrine system, and the pineal gland. Although today we can control the light in the environment, the stable functioning of our body system still depends on a 24-hour physiological, metabolic and behavioral rhythm, the circadian rhythm. Circadian rhythm, shown in Figure 3.2, is heavily influenced by light and the environment (Lyons et al., 2019; Ojamaa, 2015).

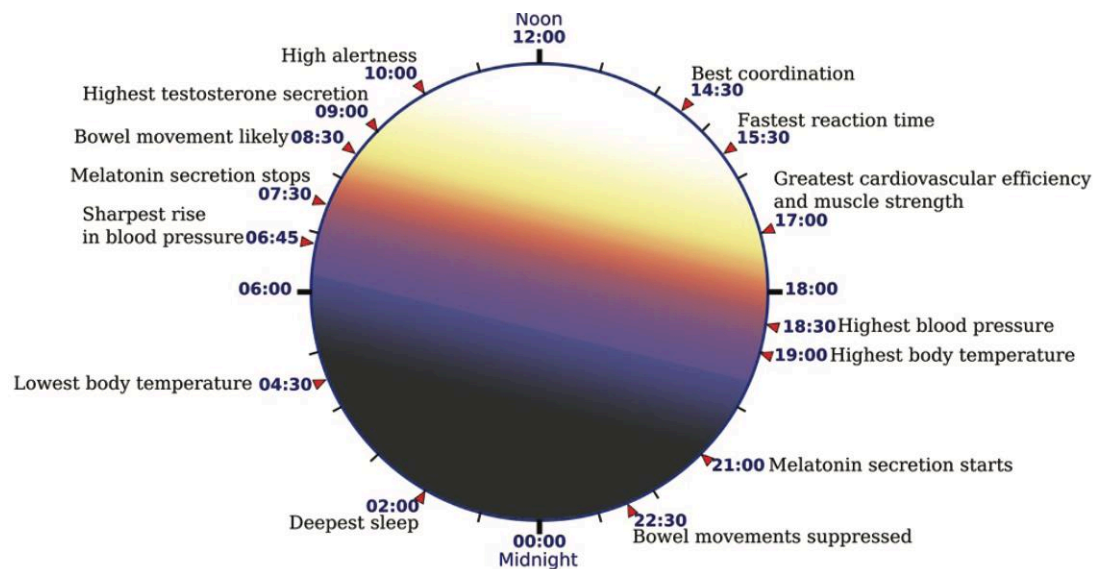


Figure 3.2 Graphic of circadian clock and circadian rhythms relation to body systems and functions (Ojamaa, 2015)

The connection between man and nature reflects the biological origin of humanity. Human development has evolved in a natural world, not an artificial one. For more than 99% of human history, human well-being and survival, the development of the senses and emotions, the development of the mind, depended on adaptively responding to the demands of the natural environment (S. R. Kellert, 2012).

Through the agricultural revolution that took place about 12,000 years ago, humans settled down and began to domesticate animals. During this period, humans began to manipulate the environment and the creatures around them as they wished. People developed the use of tools thanks to their advanced knowledge, and the first towns were established with the increase in crafts and trade. In this process, towns also developed and the first foundations of today's urbanism were laid. People's superiority over nature and damage to nature started in the ancient period when people started to settle down and destroyed meadows and pastures in order to make agriculture, and nature continued to be exploited by people (Atasoy, 2015; Kaya, 2019).

The development and variety of tools made to meet the basic needs of people prepared the ground for the Industrial Revolution, the second turning point in the cultural development of humanity. With the use of steam in production, machines replaced the human labor force. It can be said to be a turning point in the rapid increase in environmental problems, especially with the mass production and increasing urbanization that developed with the Industrial Revolution after the 18th century.

While natural conditions interfered with people's lives in previous periods, thanks to these developments, people started to direct and manage nature (Maltaş, 2015; Sulak, 2018). In this case, it is observed that the relationship between humans and nature has weakened with the increase in living comfort. Today, a large proportion of people, especially in industrialized countries, spend their time in artificial spaces such as houses, office buildings and shops (Schultz, 2002).

After the 2nd World War, people started to destroy the natural ecosystem more and more thanks to the economic growth and rapid development trends that gained global importance (Çorakçı, 2016). Through increased production, food resources became more easily accessible. With the development of the health system, people's life expectancy has increased. With the increase in the human population, consumption has increased and this has started to cause significant damage to natural resources. Wastes generated as a result of increasing industrialization cause irreversible damage to nature. As a result, all living life is under great threat today (S. R. Kellert, 2006).

In the 18th and 19th centuries, with the help of developing technology, humans dominated and exploited nature. It was only in the second half of the 20th century that people realized that the destruction of nature has consequences. The last quarter of the 20th century can be defined as a period in which the conflict between man and nature intensified, ecological and global problems became widespread, and social, cultural and economic problems increased (Çorakçı, 2016).

It is important to examine the disconnection between human and nature from a more holistic perspective in the historical process. Various social, cultural, scientific and technological developments throughout human history and the change in human population and CO₂ levels in this process are presented in Figure 3.3 and the relationship between human and nature is explained.

3.2 The Concept of Biophilia and Biophilic Design

The origin of the word biophilia is based on the ancient Greek words bio, meaning life or living things, and phila, meaning love or attraction to something. The basis of the concept of biophilia is the Ancient Greek word for “love of life - love for living things”. The concept originated in Ancient Greece, meaning “love of life”. It was first used in the 1970s by the German sociopsychologist Erich Fromm to describe the psychological tendency and attraction to life and living things (Şenozan, 2018).

The social psychologist Wilson used the term “biophilia” to explain the love of life in the context of living organisms, which is bidirectional. This two-way approach involves the protection of life from threats of death and the positive interaction between them (Wilson, 1984).

Biophilia is defined as the instinctive tendency to focus on life and life-like processes. Wilson, (2017) explains the relationship with life that is preserved after the transition from the primitive world to the new artificial environment, emphasizing that this relationship with other organisms forms the basis for learning through genetic traits.

The concept of biophilia is based on an understanding of human evolution. For more than 99% of its history, human beings have lived in hunter-gatherer groups, intertwined with other living beings. The human brain evolved in a biocentric world, not in a world regulated by machines. Modern life today is still fairly new to human history, so it is thought that humans still carry signs of biocentric life (S. Kellert & Calabrese, 2015).

Throughout human evolution, the chances of survival and continuity are related to the success of adaptation to natural conditions. Throughout the historical process, humans have developed by adapting to the conditions of nature. As a result, the collective link and sense of closeness between humans and nature explains the basis of biophilic design. According to Orr (2002), people adapt better to environments with more natural factors. Therefore, 'nature' forms the basis of the biophilic design approach (Bayraktaroğlu, 2014).

Figure 3.4 presents the conceptual development of biophilia and lists the influencing theories. Biophilia is defined as the natural human inclination or inherent instinct towards the natural world and this concept is summarized under various theoretical frameworks. The development of biophilia and the theories influencing it are considered as an important effort to understand the complex human relationship with the natural world.

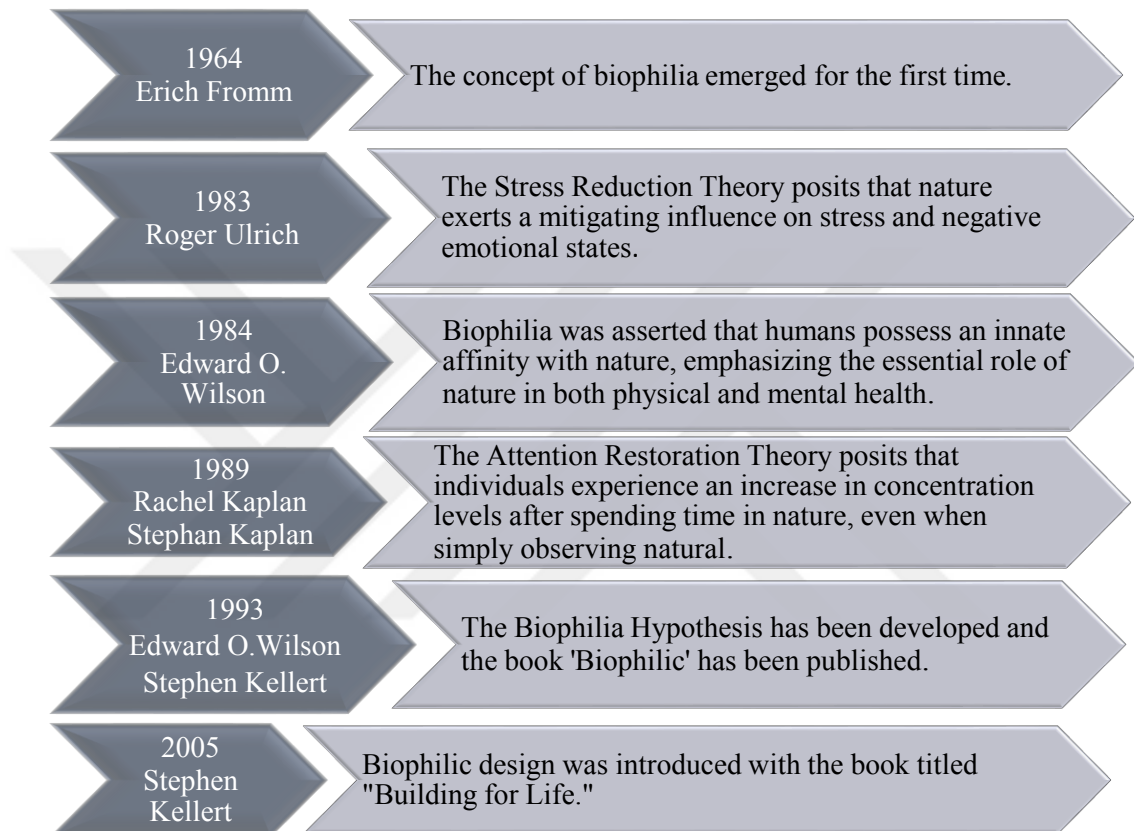


Figure 3.4 Development of the concept of biophilia and influencing theories (Demirkol & Önaç, 2021)

The concept of biophilia was first defined in 1964 by psychologist Erich From as the tendency to love nature (Myers, 2020).

In 1983, Roger Ulrich put forward the Stress Reduction Theory, which states that nature has the effect of reducing stress and negative emotional states (Ulrich, 1983). In this context, Ulrich's (1984) study is important in that it discusses positive health effects, although it does not directly refer to the term biophile. His research has provided concrete findings showing that patients who are connected to the landscape have shorter recovery times and reduced use of painkillers after surgery. These

findings make an important contribution to our understanding of the effects of natural environments on health and to our assessment of the benefits of natural environments for human health (Şenozan, 2018).

In 1984, biologist Edward O. Wilson defined biophilia in his book 'Biophilia' as 'the innate human tendency toward life and life-like processes'. In his biophilia hypothesis, Wilson (1984) explains that humans have an inherited connection with nature and that nature is a necessity for people's physical and mental health (Myers, 2020).

According to Kaplan and Kaplan's (1989) Attention restoration theory (ART), people's concentration levels increase after spending time in nature or even watching nature (Adamson & Thatcher, 2018). Natural environments effectively restore cognitive abilities, improving brain function and restoring directed attention. This allows individuals to focus, make decisions, think creatively and process information more effectively (Johnson et al., 2022). “Soft fascination”, an important element of ART, refers to paying attention to soft fascinating stimuli that require little effort and leave room for reflection and renewal. The theory also suggests that a sense of connectedness to nature plays a role in the restoration process, as individuals who feel higher connectedness to nature report feeling more refreshed after seeing natural images. In general, ART supports the importance of natural environments and their benefits in restoring attention and enhancing well-being (Burn & Passmore, 2022).

In 1993, Edward O. Wilson and Stephen Kellert expanded the Biophilia Hypothesis and published the book “Biophilia” (Demirkol & Önaç, 2021).

In 2005, Stephen Kellert introduced the concept of biophilic design in his book “Building for Life: Designing and Understanding the Human-Nature Connection” and developed more than 60 design criteria aiming to enable people to experience nature through architectural designs in direct, indirect and spatial ways (S. R. Kellert, 2005).

In 2008, Kellert published the book “Biophilic Design” in which he specifically addressed this concept. This book included articles by researchers who will contribute to the field. Kellert defined “Biophilic Design” as “*the consideration of the intrinsic human connection to nature for the design of the built environment.*” (S. R. Kellert et al., 2008).

Biophilic design refers to building and landscape design that incorporates natural elements to enhance human well-being and promote a positive connection between humans and the natural environment. Biophilic design aims to create a positive and valued experience of nature in the man-made environment, which is crucial for sustainable and environmentally friendly development (S. R. Kellert, 2005).

Biophilic design is an innovative approach that emphasizes the importance of maintaining, enhancing and recovering the positive effects of nature in the built environment. This perspective recognizes that humans evolved in response to natural conditions and stimuli and that contact with nature is critical to health, well-being and productivity. Biophilic design is not limited to simply adding greenery to buildings; it aims to integrate the natural environment into the design process to create functional, aesthetic and long-lasting structures using local materials, natural themes and patterns. The goal of this approach is to achieve a situation where a sustainable and fulfilling modern society exists in harmony with nature, with mutual benefit between the natural and artificial environments (S. R. Kellert et al., 2008).

The effective application of biophilic design contributes to the sustainability of the built environment while significantly enhancing both physical and mental well-being. On the physical side, benefits include enhanced physical fitness, reduced blood pressure, increased comfort and satisfaction, fewer illness symptoms, and overall better health. Mentally, biophilic design fosters higher levels of satisfaction and motivation, reduced stress and anxiety, improved problem-solving and creativity, positive behavioral changes, enhanced coping mechanisms, greater mastery skills, and heightened attention and concentration. (Kellert & Calabrese, 2015). Accordingly, the influence of biophilic design to create a positive and valued experience of nature in the human-made environment promotes a connection to the natural world while enhancing human well-being. Incorporating natural elements such as natural lighting, ventilation and materials into design is scientifically proven to improve mental health, productivity and cognitive function. This approach also contributes to sustainability and environmental protection because it encourages the development of a deep appreciation and understanding of the natural environment, resulting in more responsible resource use and a reduced ecological footprint. Integrating biophilic design into buildings and landscapes reflects the local culture and environment, establishing the identity of the place and enhancing the overall aesthetic appeal of the

man-made environment. It also contributes to the economic and social well-being of communities. Because it creates attractive and lively spaces to which people are emotionally and intellectually connected, which encourages increased participation and investment in the surrounding area (S. R. Kellert et al., 2008; Narula, 2024).

S. R. Kellert (2008) examined biophilic design elements in two basic dimensions: “Organic or Naturalistic” and “Place-based or Vernacular”. The Organic or Naturalistic dimension is defined as the direct and symbolic interaction of human beings with elements such as sunlight, ventilation, plants, water, etc., which are necessary for human survival. The Place-based or Local dimension refers to the connection of architecture with culture and ecology in a specific geographical and local context. These two dimensions can be explained under 6 main headings in a total of 72 designs in Table 3.1

Table 3.1 Elements of Biophilic Design according to Kellert (2008)

Environmental Features	Colour Water Air Sun light Plants Animals Natural materials View Facade Greening Geology and Landscape Habitat and Ecosystem Fire	Light and Space	Natural light Filtered and Diffuse Light Light and shadow Reflected Light Light pool Warm light Form of light Width (Refreshment) Spatial Diversity Form of space Spatial harmoy Indoor and Outdoor Relationship
	Botanical Motifs Tree and Vertical Transports Animal Motifs Shell and Spirals Arches, vaults, domes Oval and Round Shapes Straight and Non-Right Angle forms Simulation of Natural Characteristics Biomorphology Geomorphology Biomimicry		Geographical connection the place Historical connection with the place Ecological connection with the place Cultural connection with Space Local Materials Geo-Orientation Landscape features that shape the building Landscape ecology Integration of Culture and Ecology Spirit of Space Avoiding placelessness Shelter and Vigilance
Natural Spaces and Forms	Sensory Diversity Information Richness Aging, Change, traces of time	Evolutionary Human-Nature Relationships	Order and Complexity Creating Curiosity and Excitement Change and Metamorphosis Security and Protection Domination and Control Emotional intimacy and commitment Charm and Beauty Discovery and Invention Information and Cognition Fear and admiration Respect and Spiritual Religiousness
	Growth and Reproduction Central Focal Point Patterned wholes Restricted spaces Transition spaces Linked and serial chained spaces Integration of the part into the whole Complementing opposites Dynamic Balance and Tension Fractals Hierarchical ratio and proportion		

S. Kellert and Calabrese (2015) have simplified the biophilic design criteria put forward by Stephen Kellert in his book “Building for Life: Designing and Understanding the Human-Nature Connection”. These elements and the design strategies to achieve them are summarized in Table 3.2.

Table 3.2 Elements of Biophilic Design according Kellert and Calabrese (2015)

	Design Elements	Design Strategies
Direct experience of nature	Light	Using glass walls, interior windows, reflective colors and materials
	Air	Opened windows, technological systems (ventilation, air cleaner, etc.)
	Water	Water masses, fountains, aquariums (if it's clean and active, it appeals to multiple senses)
	Plant presence	Indoor plants, green roofs, green walls
	Animals	-
	Natural landscapes and ecosystems	Ecosystems, built wetlands, forest grasslands, simulated aquatic environments, observation towers
	Fire	Fireplace
Indirect experience of nature	Natural views	Plant-animal-natural landscape-water-geological painting, painting, video, computer simulation, sculpture
	Natural materials	Wood, stone, wool, cotton, leather, etc.
	Natural colours	Especially soil tones, natural colors, artificial contrast colors should be avoided.
	Simulation of natural light and weather	Similar to natural light and air.
	Natural shapes and forms	Leaf-like patterns on columns, plant shapes on building facades, animal replicas woven into fabrics and coverings, etc
	Imitation of natural shapes and forms	Abstraction and creative fantastic imitation of shapes and forms in nature
	Wealth of information	Opportunistic and rich in information space,
	Change, age, patina of time	Aging materials, changing weather conditions, a sense of the passage of time
	Natural geometries	Geometric shapes, fractals, golden ratio, Fibonacci sequence
	Biomimicry	It is used by living things in nature and can be adapted to provide human needs. Structural strength of spider web, heat control of thermal mounds etc.
Experience of the place	Prospect and refuge	Balance of view and hide
	Organized complexity	Organized and regularly experienced spaces that tend to have complex qualities
	Integration of parts into the whole	The spaces formed by the pieces with the focal point
	Mobility and wayfinding	Easily perceived paths
	Cultural and ecological commitment to the place	Endemic fauna, flora species and designs reflecting local culture

Cramer and Browning (2008) identified three basic elements to define biophilic design criteria. These elements are listed as “Nature in Space”, “Natural Analogues” and “Nature of Space”. These elements are summarized in the Table 3.3

Table 3.3 Elements of Biophilic Design according Cramer and Browning (2008)

Design Elements	Design Strategies
Nature in Space	The inclusion of plants, water elements, and animals in the design of a space is one way to create a biophilic environment. In large-scale spaces, terraces, courtyards, indoor gardens, green roofs, and the use of water elements are among biophilic design elements, while in small-scale spaces, potted plants and aquariums are used. The use of nature-themed paintings and photographs also serves as another way to symbolically reflect nature within spaces
Natural Analogues	Defined as design features that evoke certain aspects of nature. These include decorations made using natural materials and analogues, such as leaves, flowers, fruits, seashells, and animal forms used in architectural ornamentation. While these forms were more commonly used in designs before modern architecture, their place in modern architecture has largely been replaced by the simple use of natural materials
Nature of the Space	One way to evoke a biophilic response in people is by exploring their reactions to spatial patterns. There are historical and contemporary examples of using the “prospect and refuge” concept in architectural design. For instance, spaces where people feel safe and can perceive surrounding events can be described in this context. A hearth (a large fireplace commonly found in 17th-century English houses and cottages that provided a sense of partial enclosure, especially in spaces with high ceilings) serves as a place of refuge while allowing for observation of the surrounding landscape and events

Ryan et al. (2014) developed and improved upon the work of Cramer & Browning (2008) This design model is the result of an extensive literature review. It is also highly applicable for both indoor and outdoor spaces. (Table 3.4).

Table 3.4 Elements of Biophilic Design according Ryan et al. (2014)

Design Elements	Biophilic elements
Nature in Space	Visual connection with nature Non-visual connection with nature Non-rhythmic sensory stimuli Thermal and airflow variability Presence of water Dynamic and diffuse light Connection with natural systems
Natural Analogues	Biomorphic forms and patterns Material connection with nature Complexity and order
The Nature of the Place	Prospect Refuge Mystery Risk / peril

4 History of the Office Concept

The words "office" and "bureau" both originate from French. "Office" means "duty" or "duty station." This word derives from the Latin word "officium." "Officium" is rooted in the Latin word "opificium," although no written example of this word exists. Its origin is the word "opus," meaning "work, task." "Opus facere" means "to do business." The French word "bureau" means "linen-covered writing desk, writing office, office, government office." This word is derived from the Old French word "bure" (a type of woolen cloth or felt) (Çimen, 2008) .

According to the Cambridge Dictionary, "office" is defined as a room or part of a building where people work, especially sitting at a desk with computers, telephones, etc., usually used as part of a business or other organization (Cambridge Dictionary, 2024).

An office may be defined as the physical space where the services of an organization are provided. Offices, which are generally used as workplaces, represent an environment where various activities are carried out, where staff come together, and where information exchange and cooperation are ensured. Therefore, the term office is considered an important concept related to the functioning and activities of a business or organization (Cunliffe & Raymond, 1997).

In short, office spaces can be characterized as places of various scales where individuals work in groups or individually.

The evolution of offices has evolved with social, cultural and historical events. In order to respond to different uses and needs, office spaces have transformed over time and have been transformed by the impact of technology. Factors such as the increased participation of women in the workforce, increasing social demands and technology enabling flexible working models have changed the design and requirements of offices.

These changes have led to differences in the design of office interiors and work processes. This transformation has transformed offices from being just places to do

business to spaces that meet the needs and expectations of employees and aim to increase productivity.

Early examples of office spaces are the Palazzo degli Uffizi built by G. Vasari in Florence in 1558-1560 and the Bank of England built by George Sampson in England in 1694 as seen in Table 4.1 (Okumuş, 2016).

Table 4.1 The first office examples in the world

 Palazzo degli Uffizi ((La Storia Degli Uffizi - Le Origini Del Grande Museo,2024)	 Bank of England (View, England, London, Bank of England, Antique Print, Ackermann's, London, 1816 – George Glazer Gallery, Antiques,2024)
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The bourgeois class, which engaged in trade and became richer in the Middle Ages, brought office spaces back to the agenda. The lower floors of the houses facing the street side were used for commercial and office purposes, while the upper floors served as residences. This is an early example of the first workspaces of the private sector (Dalga, 2007).

The Industrial Revolution led to an increase in the number of corporate companies, which in turn increased the demand for workspace. This has provided an impetus for the creation of office spaces. However, this change has also led to a transformation of workspaces in modern cities (Demirkol & Önaç, 2021).

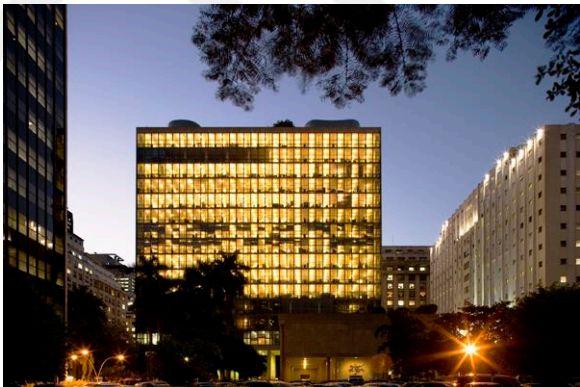
Built in Chicago between 1884 and 1885, the Home Insurance Building was designed and built by William Le Baron Jenney. This building is considered one of the first examples of modern office buildings. It is also recognized as the world's first true skyscraper (Sullivan, 1922).

Designed in 1904 by Frank Lloyd Wright in Buffalo, New York, the Larkin Building became a model for subsequent building designs in many areas. This specially designed building is notable for housing 1800 secretaries, clerks and managers both efficiently and comfortably. The most important feature of the building is that it has wide openings, leaving very little private space for employees. For this reason, an additional building with showers and lockers was built. Separate toilets were built for men and women working in the building. A medical unit, a rest room, a seminar room and a library were also designed (Altınkoç, 2005).

With the Second World War triggering a global economic crisis, there was a two-decade-long construction recession. During this period, post-war architectural environments continued pre-war design methods guided by predetermined functionality, which reached its peak in the 1950s. Particularly in the 1920s, representatives of the European modern movement sought to emulate the modern office design of the United States, redesigning and rebuilding the style with minimal resources. Designs such as the “crystalline glass tower” and the “concrete office building” by Mies van der Rohe influenced American corporate architecture after the war. Likewise, Le Corbusier's Ministry of Education and Health building in Rio de Janeiro in 1936 played an important role in the development of glass architecture worldwide. This project reflected the ideals of a more transparent and democratic organization by considering the use of glass in architectural design from a new perspective. This process had a significant impact on the architectural and functional transformation of office buildings (Rassia & Rassia, 2017).

Table 4.2 presents the first examples of modern office buildings around the world.

Table 4.2 First examples of modern office buildings

	
Home Insurance Building (Home Insurance Building - The Skyscraper Center,2024)	Wainwright Building (Gallery of AD Classics: Wainwright Building / Adler & Sullivan – 8,2024)
	
Larkin Building (Romanticism to Ruin: The Larkin Administration Building - Chicago Reader,2024)	Ministry of Education and Health Building (Architectural Brazil: 10 Breathtaking Modern Monuments, 2024)

In the 1950s, the development of open-plan offices, referred to as the “American century” of the office, was initiated by the so-called “Bürolandschaft” (Figure 4.1) developed in Germany (Hamburg). This approach was based on a new model of interior design against traditional views and promoted egalitarian and non-hierarchical work interaction by encouraging human relationships. This model was based on the

free arrangement of furniture and office uses in a largely open plan layout. This design strategy aimed to increase flexibility in the use of office space and strengthen communication between employees (Dalga, 2007; Rassia & Rassia, 2017).

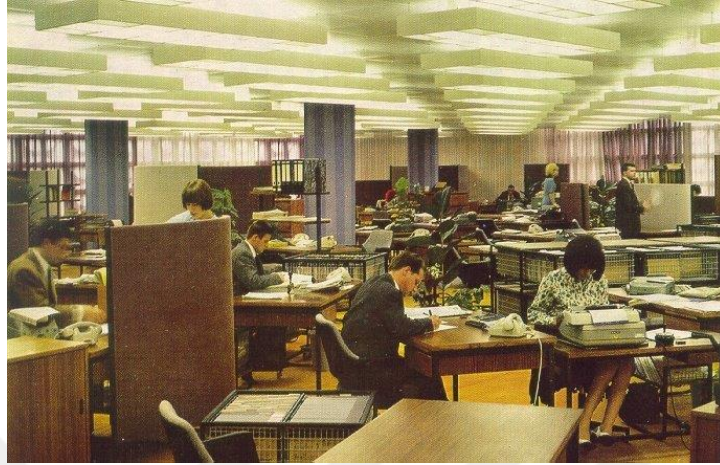


Figure 4.1 Bürolandschaft (Bürolandschaft: Damals Ihrer Zeit Voraus, Heute Relevanter Denn Je! – Combine Consulting, 2024)

In the 21st century, work life is a significant part of people's daily routines, and in this context, most individuals spend a significant portion of their time in closed office environments. This reality emphasizes the critical importance of office design. The potential negative effects of these environments can be observed in individuals who work in closed spaces for long periods of time. In this context, companies are focusing on factors that increase employee productivity. Today, office designs aim to increase the productivity and health of employees to support business processes. Towards these goals, important elements in office design include information sharing, collaborative working, leveled hierarchy, mobility and technology çıkmaktadır (Eid, 2006).

5 Biophilic Office Design

Nowadays, construction is an important factor that causes people to move away from nature. Biophilic design aims to prevent this disconnection and improve people's quality of life by integrating natural elements into interiors. Biophilic design principles include elements such as the use of environmental qualities, the integration of natural forms, the use of natural textures and processes, the use of light, the organization of spatial relationships and the reflection of the human-nature relationship in spaces. Biophilic design is a comprehensive approach to the design of the built environment that is not limited to the inclusion of natural plants. This approach is based on the principle of integrating the physical, sensory, metaphorical and morphological elements of nature into the structure. Therefore, it offers a structurally and aesthetically rich design approach inspired by various aspects of nature, not limited to plants. This comprehensive approach aims to strengthen the human connection with nature and create a sense of a natural environment in interiors (Demirkol & Önaç, 2021; Zhong et al., 2022).

Effective implementation of biophilic design contributes to the sustainability of the built environment as well as improving people's physical and mental health. In terms of physical health, biophilic design practices increase individuals' physical fitness levels, lower blood pressure, increase comfort and satisfaction levels, reduce disease symptoms and improve overall health. On the mental side, biophilic design practices lead to increased satisfaction and motivation, reduced stress and anxiety, associated increased problem-solving and creative abilities, positive behavioral changes, more effective coping with stressors, increased skill levels, and higher levels of attention and concentration. In this way, biophilic design contributes to the sustainability of the environment while enhancing people's overall health and well-being, as well as improving their mental performance and quality of life (S. Kellert & Calabrese, 2015; Wijesooriya & Brambilla, 2021).

The adaptation of office spaces according to biophilic design principles provides significant benefits that improve the quality of life of employees. Research shows the effects of this design approach such as increased positive mood, increased performance and productivity, and increased concentration levels. Office environments designed in

accordance with biophilic design principles encourage the use of natural elements in interiors and interaction with nature. This design approach, in conjunction with the natural attraction of humans to natural environments, positively affects the mood of employees. This contributes to employees feeling happier and more satisfied at work. Research also shows that biophilic design improves employee performance and increases their concentration. The presence of biophilic elements in office environments, such as access to natural light sources, the use of green plants and the view of natural landscapes, increases employees' mental well-being and reduces stress levels (Gray & Birrell, 2014).

5.1 Examples of Offices Based on Biophilic Design Criterias

Glumac's Shanghai office and Kickstarter's commercial center were selected as examples of biophilic office designs, and the biophilic design elements in these offices were examined in detail. These examples show how biophilic design is applied in workspaces and the integration of natural elements into interiors.

5.1.1 Glumac's Shanghai Office

The Glumac office in Shanghai, China, was designed by Terrapin Bright Green, Gensler, Japanese construction partner Shimizu and Shanghai-based green materials consultant GIGA. The office space is half of the third floor of a four-storey, 4,650-square-meter, 100-year-old building of 4,650 square meters, which is part of a campus development called 753 Jia Chun Park, located on Yuyuan Road in Shanghai's Changning District (Figure 5.1). The park was built in 1912 as a vacation spot for the Rockefeller family and is filled with abundant vegetation and mature trees (Glumac Shanghai Office , 2016; New Steps for Sustainability: Glumac Brings the Living Building Challenge to Asia - Glumac, 2025).

Designed in accordance with Platinum CI v4 standards and full-flower Living Building Certification (LBC). This design is the first Net-Zero Energy, Water and Carbon project in Asia to achieve the highest sustainability standards (Glumac Shanghai Office TI | U.S. Green Building Council, 2025).



Figure 5.1 Glumac'in Şanghai of (New Steps for Sustainability: Glumac Brings the Living Building Challenge to Asia - Glumac, 2025)

Biophilic design elements Visual Connection with Nature, Connection with Natural Systems, & Diffuse Light and Biomorphic Forms & Patterns Dynamic were used in the office design (*Glumac Shanghai Office* , 2016).

Figure 5.2 shows the interior design of the office.

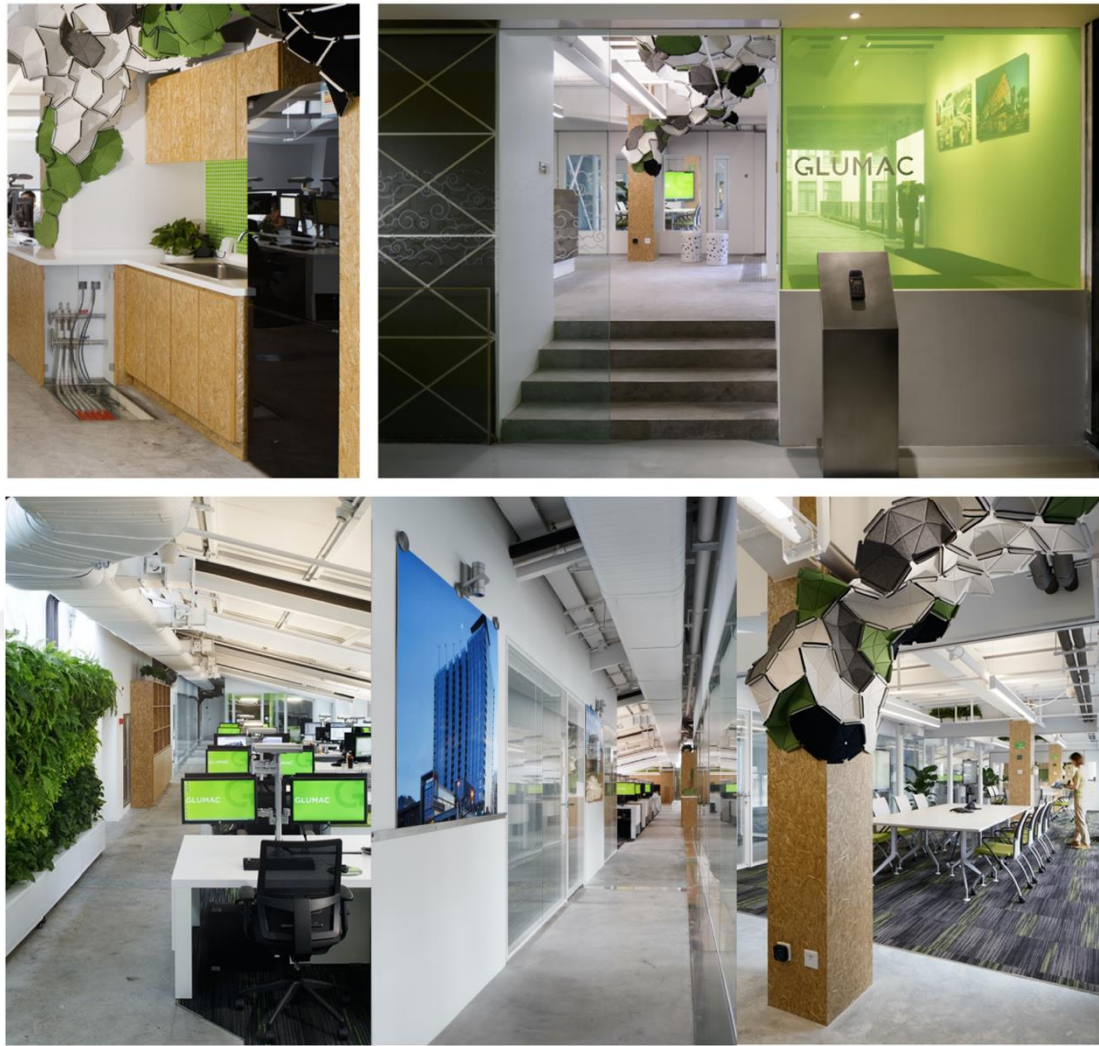


Figure 5.2 Interior design of Glumac's Shanghai office (Glumac Shanghai Office TI | U.S. Green Building Council, 2025; Glumac Shanghai Office , 2016)

Click or tap here to enter text. Visual Connection with Nature: Every desk in this office enjoys a view through one of the many large windows. Meeting rooms and collaboration spaces feature floor-to-ceiling windows and glass doors that lead to a plant-filled terrace. This terrace serves as a multifunctional space, accommodating both offices and events. A wall adorned with *Sansevieria trifasciata* and various other potted plants enhances the window views, providing users with close contact with nature and the opportunity to observe plant growth and evolution over time (Glumac Shanghai Office, 2016).

- **Dynamic & Diffuse Light:** The office floor plan is meticulously designed to maximize daylight, reducing energy requirements and meeting net-zero energy standards. The space is bathed in natural light throughout the day, promoting

environmental awareness among workers. Technologies such as electric lamps triggered by automatic sensors and dynamic glazing allow users to control light levels, while the natural variation of light and shadow ensures a comfortable and efficient working environment (*Glumac Shanghai Office* , 2016).

- **Connection With Natural Systems:** The office integrates water, waste, and electricity systems in harmony with natural processes, raising employee awareness of seasonal and temporal changes. The rainwater collection and filtration system, along with the dehumidification system, provides recycled water for toilets, the bistro, and office plants. This direct connection to water sources enables employees to monitor seasonal variations in rainfall and humidity. Additionally, solar photovoltaic panels on the roof, visible through large windows, highlight the seasonal changes in sunlight. Compost toilet topsoil is used as fertilizer for indoor and outdoor plants, contributing to the nutrient cycle. For Shanghai residents concerned about poor air quality, the office offers an app that displays real-time indoor and outdoor air quality, encouraging safe outdoor activities and interaction with the environment (*Glumac Shanghai Office* , 2016).
- **Biomorphic Forms & Patterns:** The office features a Kvadrat cloud, a crystalline structure composed of green, white, gray, and black acoustic panels that ascend walls and ceilings, softening the space's hard edges. Each polygon consists of five triangles forming a pentagonal pyramid. The cloud not only serves as a visual spectacle but also absorbs sound in areas with exposed concrete floors. The design incorporates traditional Chinese lucky clouds, symbolizing good fortune and happiness, represented by abstract curves on the glass entrance door. Opposite the reception desk, two classic Chinese garden stools, painted white and intricately carved with curved patterns, enhance the cultural connection. The office carpet features organic forms resembling water flow or wool clouds, mirroring the contoured, patterned, and textured arrangements found in nature (*Glumac Shanghai Office* , 2016).

5.1.2 Kickstarter Commercial Headquarters

The Kickstarter Commercial Centers in Brooklyn, New York (Figure 5.3) was designed by local architect Ole Sondresen. This design involves the conversion of a former pencil factory with an area of 2,695 square meters. The building features a usable green roof, gallery, theater, office spaces and library (Kickstarter — Ole Sondresen Architect, 2025.; Kickstarter Commercial Headquarters, 2016).



Figure 5.3 Kickstarter Commercial Headquarters (Kickstarter's Office at 58 Kent Is on Sale for \$25 Million, 2024)

Connection with Natural Systems, Material Connection with Nature, Prospect & Refuge, Non-Rhythmic Sensory Stimuli, from biophilic design elements were used in its design (Kickstarter Commercial Headquarters, 2016). Figure 5.4 shows the interior design and green roof of the office.



Figure 5.4 Kickstarter Commercial the interior design and green roof of the office. (Kickstarter — Ole Sondresen Architect, 2025.; Kickstarter Commercial Headquarters, 2016).

- **Non-Rhythmic Sensory Stimuli:** Each floor is designed to support the local ecosystem, fostering a connection between employees and their environment. The use of native plants provides habitats for local and migratory birds. The stochastic and transient movements of flora and fauna add complexity and interest to the workplace environment. Moving grasses, falling leaves, fluttering butterflies, and occasional birdsong create a relaxing atmosphere for workers. Curtains between the ceiling and the floor allow users to experience this changing landscape from their desks and common areas. All spaces outside the theater are designed to have a direct or indirect relationship with the courtyards and rooftops. (Kickstarter Commercial Headquarters, 2016).
- **Connection with Natural Systems:** The design emphasizes the seasonal and temporal characteristics of a functional ecosystem, linking the building and its occupants to their natural surroundings. Plant species in the courtyards and terraces are selected based on their sun exposure, and the use of edible plants encourages seasonal interaction. Cascading courtyards and rooftop gardens mimic lost habitats once abundant in Brooklyn. The lowest courtyard serves as a shaded rain garden, capturing water from the building's roof to recreate the wetland habitat previously prevalent in the area. This approach showcases the practical application of the Connecting with Natural Systems pattern by using

the courtyard as a rain reservoir, allowing employees to observe natural processes and cycles and supporting biodiversity. Employees have both visual and physical access to these natural systems through windows and doors on each floor (Kickstarter Commercial Headquarters, 2016).

- **Material Connection with Nature:** In the design, recycled natural and locally reused wood is often used, reflecting the local ecology and geology. Hardwoods such as oak, which grow in the region, are used in the building's interior design, while walnut and cedar, which are resistant to decay, are preferred for exterior cladding. The dark wood used for the theater is obtained by oxidizing the oak previously used in the building (*Kickstarter Commercial Headquarters*, 2016).
- **Prospect & Refuge:** The open plan on the main floor provides views of the indoor working environment and the courtyard at the building's center. The second floor offers views of the main workspaces, the balcony terrace, and the central courtyard. The rooftop provides views of the courtyard, the workspace, and the surrounding buildings and landscape, connecting employees with the neighborhood. Additionally, the library is designed as a quiet retreat for employees, providing a stark contrast to the expected workplace conditions (Kickstarter Commercial Headquarters, 2016).

6 Materials and Method

The aim of this study is to examine the effects of office environments developed based on biophilic design criteria on individuals' stress levels and well-being in the light of cognitive and physiological evidence. The study design, sample, materials and methods are presented in detail below.

6.1 Research Design

The methodology of the research is presented in detail in Figure 6.1.

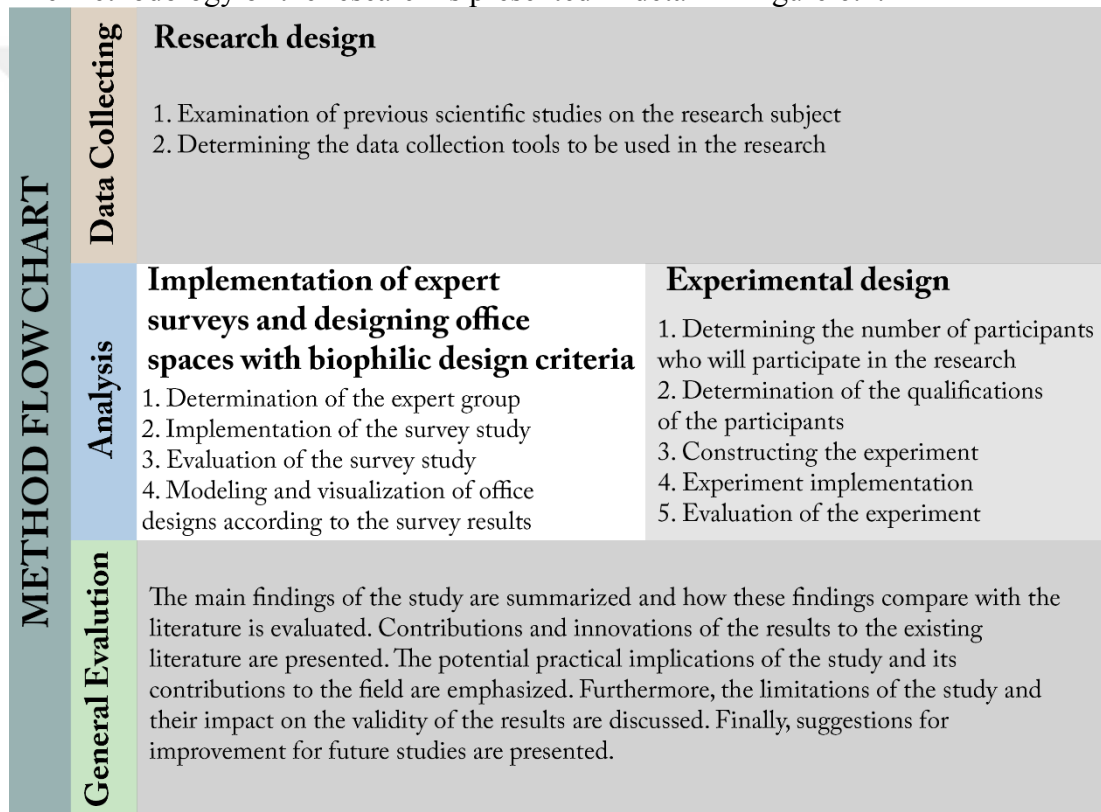


Figure 6.1. Method flowchart

In the first stage of the study, the data collection stage, the literature on the subject was reviewed and the research hypothesis was formulated. Data collection tools were determined in line with the information obtained from the literature review. The dependent and independent variables to be used in the study are given below.

Dependent variables: “State Anxiety Scale” and ‘D2 Attention Test’ results, blood pressure, pulse/min, respiratory rate/min, body temperature, partial oxygen pressure, EEG monitoring, salivary cortisol

Independent variables: Participants' socio-demographic data, office designs with biophilic design elements, office design without biophilic design elements (control group) expert survey data.

In the first part of the analysis phase, which is the second phase of the study, an expert group consisting of psychologists, psychiatrists, architects, landscape architects and interior architects is formed. Then, the expert questionnaire prepared in line with the literature data (Appendix A) was applied online to this group. According to the results of the expert survey, it was determined which of the biophilic design elements should be included in the virtual office environments to be designed for the experiment phase.

In the experiment phase, which is the second part of the analysis phase, each virtual biophilic office and control group office designed according to the data obtained from the expert questionnaire study were shown to the participants via VR. The experiment procedure is shown in Figure 6.2.

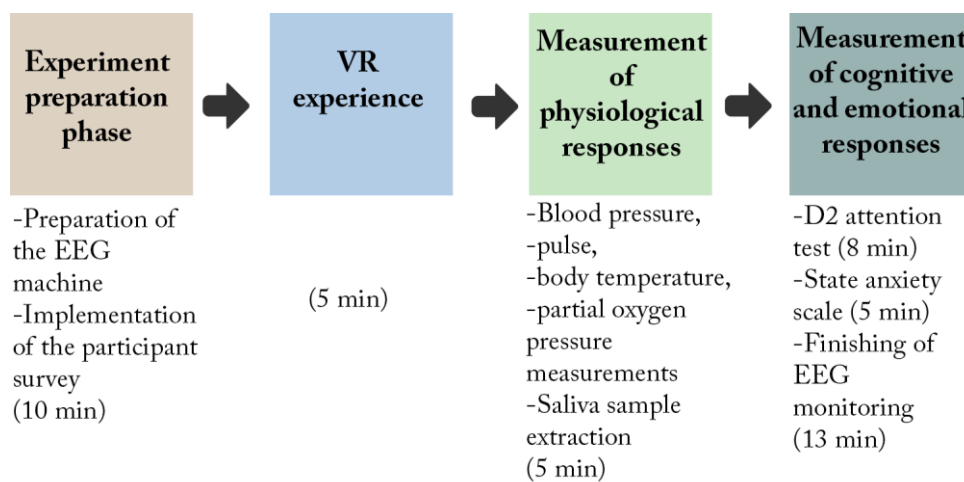


Figure 6.2 Procedures and applications used in the study

Thirty participants were voluntarily selected for the experiment. In the preparation phase of the experiment, the participants were fitted with the electrodes required for EEG monitoring. Then the participant questionnaire (Appendix B) was applied. After the participant questionnaire was applied, EEG monitoring was started. In order to measure the cognitive and emotional responses of the participants before the VR

experience, blood pressure, pulse/min, respiratory rate/min, body temperature/C°, partial oxygen pressure mmHg were measured to measure the physiological responses of the subjects. Saliva samples were taken for the measurement of salivary cortisol level. The D2 Attention test (Appendix C) and the State-Trait Anxiety Inventory (STAI) (Appendix D) were then administered. Each participant experienced the virtual office with and without biophilic design elements with the same procedure, and the experiment was applied crosswise to the participants.

After the experimental phase was completed, all results were evaluated and discussed.

6.2 Sample Group

6.2.1 Sample group of expert surveys

The universe of the research consists of members registered in certain professional groups. In this context, there are a total of 63,628 registered members in the field of architecture. Landscape architects are represented by 6,419 registered members, while the interior architecture profession has a total of 6,249 members. The number of registered members of psychiatrists is 4,975, while the number of registered members of psychologists is 6,480. The total number of registered members of these five occupational groups defines the universe that constitutes the scope of the research as 87,861 people in total. These data were obtained from professional chambers and relevant associations. The number of architects, interior architects and landscape architects was obtained from TMMOB's website (TMMOB, 2020). The number of industrial design commission members affiliated to TMMOB was obtained through the application made to TMMOB. The number of psychologists was reached through the June 2021 activity report of the Turkish Psychologists Association (TPD, 2021). The number of psychiatrists was reached through a phone call to the headquarters of the Turkish Psychiatric Association.

The sample size was determined with a 5% margin of error and 95% confidence interval. As indicated in Table 6.1, stratified proportional distribution sampling method was used on the basis of occupational group.

Determination of the sample:

Study population: Architects, interior designers, landscape architects, psychiatrists and psychologists registered with institutions and organizations in Turkey

N: Number of universe units, n: Sample size

P: The rate at which X is observed in the universe, Q (1-P): The rate at which X is not observed

$Z\alpha$: $\alpha = 0.05, 0.01, 0.001$ for 1.96, 2.58 and 3.28 values

d= Sampling error

σ = Universe standard deviation (Kalaycı, 2010).

$$n = \frac{N \cdot \sigma^2 \cdot Z^2}{(N - 1) \cdot d^2} \quad n = \frac{P \cdot Q^2 \cdot \alpha}{d^2} \quad (6.1)$$

Table 6.1 Sample size

Profession	Number of registered members of the association or chamber	95% confidence interval	Number of surveys to be applied
Architect	63.628	383	278
Landscape architect	6.419		28
Interior architect	6.249		27
Psychiatrist	4.975		22
Psychologist	6.480		28
Total	87.861		383

As seen in Table 6.1, surveys were conducted for each occupational group. A total of 278 questionnaires were administered in the architectural profession. For landscape architects, 28 surveys were conducted, while 27 surveys were completed for interior architects. For psychiatrists, 22 questionnaires were administered, while 28 questionnaires were completed for psychologists. As a result, a total of 383 questionnaires were administered covering five professional groups.

6.2.2 Sample group of experiment

The experimental part of the study was conducted with 30 participants who met the research criteria detailed below. Participants were asked to participate in the study voluntarily. Participants were also informed about the purpose of the study,

confidentiality, volunteering and withdrawal. Participants were asked to mark a statement declaring their voluntary participation before starting the study, and no surgical intervention or any invasive intervention was performed in the study.

The inclusion criteria are as follows.

- Who agreed to participate in the research,
- Not suffering from any hormonal disease,
- Do not have a psychiatric illness and do not use any medication for therapeutic purposes,
- Non-sleep disturbance,
- No visual impairment at a level that would affect the experiment,

Do not have heart disease and do not use any medication for therapeutic purposes,

- Does not have hypertension/hypotension and does not use any medication for treatment,
- Who had not consumed caffeine on the day of the experiment,
- Who had slept 7-9 hours before the day of the experiment,
- Normal body mass index ($18.5 < \text{Body Mass Index (kg/m}^2) < 25.0$).

Each participant who participated in the experiment signed a form declaring that they met the inclusion criteria and voluntarily participated in the study (Appendix E)

Table 6.2 Variables related to sociodemographic of experiment participants'

Variables		N	%
Gender	Female	14	46.70
	Male	16	53.30
Age range	24-34	18	60.00
	35- up	12	40.00
Marital status	Single	17	56.70
	Married	13	43.30
Education status	Bachelor's Degree	9	30.00
	Master's Degree	12	40.00
	Doctoral Degree	9	30.00
Occupation	Academician	17	56.70
	Student	6	20.00
	Others*	7	23.30

**Other; Electrical Engineer, Electrical Technician, Occupational Health and Safety Specialist, Civil Servant, Architect, Landscape Architect*

46.70% of the participants were female and 53.30% were male. 60.00% were between the ages of 24-34, while 40.00% were 35 years and over. 56.70% of the participants were single, 43.30% were married. According to their educational background, 30.00% of the participants have a bachelor's degree, 40.00% have a master's degree and 30.00% have a doctorate degree. In terms of occupational distribution, 56.70% of the participants were academicians, 20.00% were students, and 23.30% belonged to other occupational groups (Table 6.2).

6.3 Materials

In this study, various tools and programs were used in data collection and analysis processes. The State Anxiety Scale (Appendix D) and the D2 Attention Test (Appendix C) were used to determine the attention and stress levels of the participants. Participants' physical data included blood pressure, pulse rate, body temperature and partial oxygen pressure.

These data were measured with biomonitors sensors: Beurer BM-40 for blood pressure and pulse rate, Braun PRT-2000 digital thermometer for body temperature and Beurer Po-30 pulse oximeter for partial oxygen pressure assessment (Figure 6.3).



Figure 6.3 Beurer BM-40, Braun PRT-2000, Beurer Po-30 pulse oximeter

Emotiv EPOC X -14 Channel Wireless EEG Headset (Figure 6.4) was used to collect EEG data. This device has the capability to record brain waves from 14 different channels and being wireless, it did not limit the movement of the participants.



Figure 6.4 Emotiv EPOC X-14 Channel Wireless EEG Head

EEG data were analyzed with MATLAB 2023 software. In addition, in line with the results obtained from the survey data, models of offices with and without biophilic design elements were created with 3DMAX program.

Visualization of these models with VR (virtual reality) integration was achieved using the V-Ray rendering engine. In the experimental part of the study, the participants were made to experience the designed office designs with Oculus Quest 2 256GB All-In-One Vr Virtual Reality Headset (Figure 6.5).



Figure 6.5 Oculus Quest 2 256GB All-In-One VR Headset

Statistical analyses of the processed EEG data, D2 attention test and State Anxiety Scale and physical data of the participants were performed by IBM SPSS (Statistical Package for the Social Sciences) 26.0 software.

6. 4 Data Collection Methods

In this section, the preparation and implementation of the questionnaire study; measurement of attention levels and momentary mood states; measurement of physiological parameters; EEG data; preparation and implementation of the experiment and analysis of the data are explained and presented in detail.

6.4.1 Preparation and implementation of the survey

While preparing the survey study, extensive research was conducted on biophilic design elements. In this context, the study S. R. Kellert, (2008) examined biophilic design components within two primary dimensions: Natural and Place-Based. The study explored the organic dimension by focusing on direct or symbolic human interactions with essential natural elements for human life, such as sunlight, air, plants, and water. The place-based factors aimed to determine whether architectural design aligns with specific geographical and cultural contexts. These two dimensions were further elaborated through 72 design features organized under six main categories.

S. Kellert & Calabrese (2015) optimized the biophilic design criteria outlined by Stephen Kellert in his book "Building for Life: Designing and Understanding the Human-Nature Connection." Additionally, Cramer & Browning (2008) introduced three core biophilic design dimensions to define buildings designed with biophilic principles: Nature in the Space, Natural Analogues, and the Nature of the Space. This

framework developed by Cramer and Browning (2008) was further expanded and refined by Ryan et al. (2014). This design approach is highly applicable to both interior and exterior spaces. The literature utilized during the preparation of the survey study is summarized in Figure 6.6.

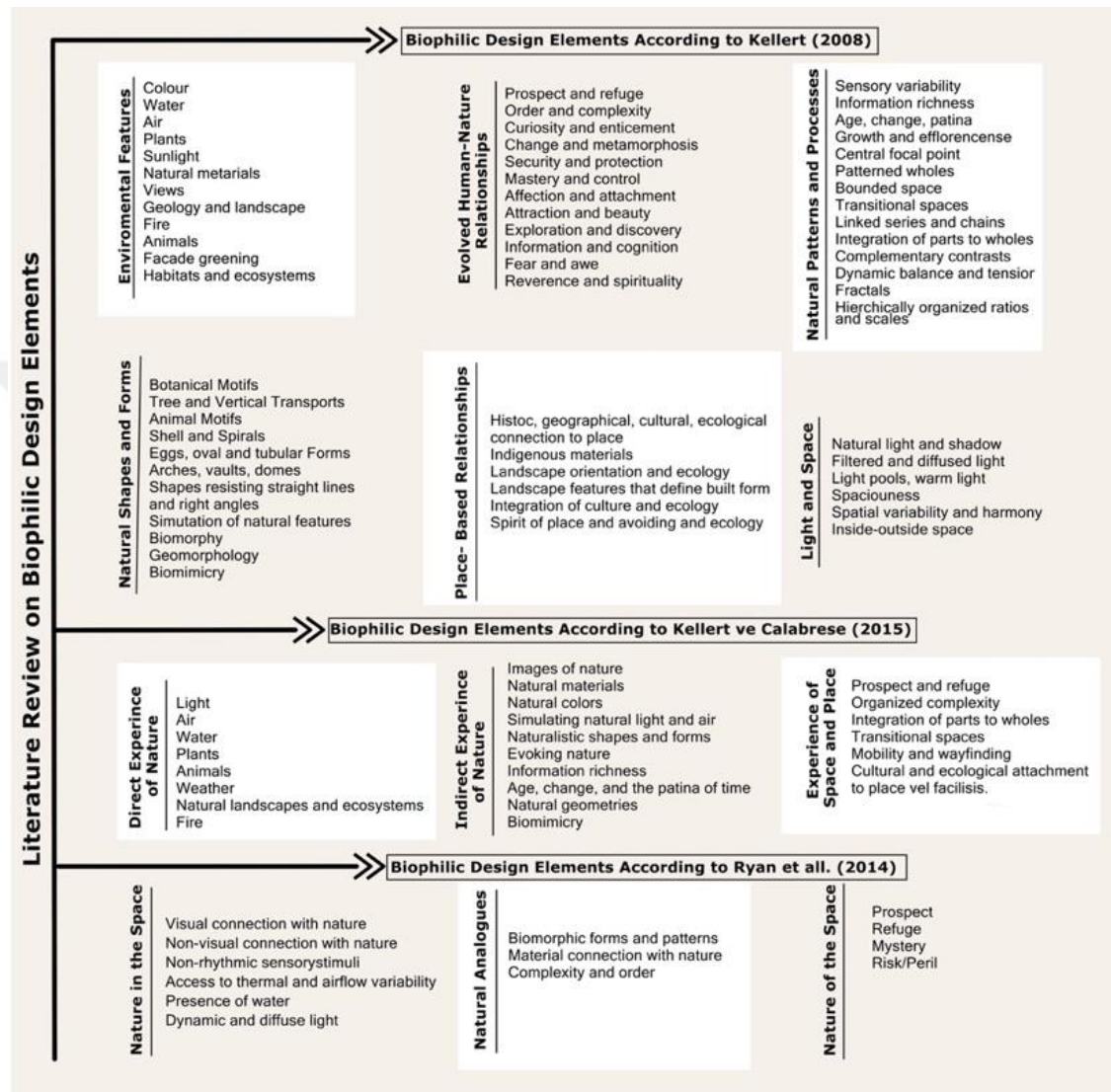


Figure 6.6 Literature review on biophilic design elements
(Kellert, S. R. (2008); Ryan et al. (2014); Cramer& Browning (2008))

The biophilic design elements specified in Figure 6.6 are integrated into office designs and summarized in Table 6.3. In line with the information obtained from the literature review, biophilic design elements that are considered suitable for adaptation to office designs have been selected and identified. The main purpose of this selection and evaluation is to identify and integrate biophilic design elements into office

environments that encourage interaction with nature in workplaces and enhance the quality of life of users.

Table 6.3 Biophilic office design elements integrated into office designs

Nature in space	Visual connection with nature	Natural view	Production of Nature	Biomorphic forms and patterns	Spiral shapes
		Fire			Straight and Non-Right Angle forms
		Pets			Organic forms
		Water			Simulation (abstraction) of Natural Features
		Plant			Using fractal geometry
					Opposites that complement each other
	Non-visual connection with nature	Aging, Change, natural materials bearing the traces of time		Objects reminding nature	Views reminding nature
		Natural colours			Objects reminding nature
		Natural sounds			
		Sensory diversity			
	Dynamic and diffuse light	Diffuse light		Material connection with nature	Local and natural material
		Day light		Complexity and order	Balance of complexity and order
				Light	Light pool

Drawing on the studies conducted by (Kellert, S. R. 2008), (Ryan et al., 2014) and (Cramer & Browning, 2008), the biophilic design elements to be integrated into office designs have been classified into two main categories: connection with nature and production of nature (Table 6.3). The "Connection with Nature" category focuses on the direct incorporation of natural components into the workspace and the establishment of an aesthetic link with the outdoor environment (Kellert, S. R. 2008). The subcategories within this section are defined as non-visual connection with nature and dynamic and diffuse light (Kellert, S. R. 2008).

The visual connection with nature element is detailed under five subcategories: the presence of plants in office spaces, the inclusion of objects related to or reminiscent of fire, the presence of pets, the use of water-related elements, and the incorporation of plants (Kellert, S. R. 2008). Under the category of non-visual connection with nature, aspects such as the use of natural materials that degrade and change over time, natural colors, natural sounds, and sensory diversity in office environments are addressed (Kellert, S. R. 2008). On the other hand, the category of dynamic and diffuse light encompasses the use of reflected light and daylight in office spaces (Ryan et al., 2014).

The "Production of Nature" category focuses on the indirect integration of natural elements into office designs, drawing inspiration from nature. This section is divided into five subcategories: biomorphic forms and patterns, objects reminiscent of nature, material connection with nature, complexity and order, and light. The biomorphic

forms and patterns category includes the use of spiral, oval, and round forms, shapes that are not straight or right-angled, designs that abstract natural elements, fractal geometry, and complementary contrasts such as light and dark hues in office designs (Cramer & Browning, 2008).

The category of objects reminiscent of nature covers the incorporation of landscape and nature-inspired objects in office designs (Ryan et al., 2014). The use of local and natural materials in office designs is examined under the material connection with nature category (Ryan et al., 2014). Complexity and order involve contemplating the balance within office designs; for example, overly empty spaces may make users feel isolated, while complex spaces may lead to feelings of discomfort and unrest (Kellert, S. R. 2008). The light category refers to the use of artificial lighting elements that simulate natural lighting in office designs (Ryan et al., 2014).

In line with this, a survey form was developed to explore the integration of biophilic design elements into office designs (Table 6.3). However, the presence of plants, a key element of biophilic design, is examined under two main categories: plant form and plant color. Within these categories, 12 subcategories have been identified. This approach emphasizes the integration of form, texture, and color elements through plant presence rather than relying on a broad range of objects. Given the visual diversity of plants, categorizing plant presence is considered essential to effectively convey this diversity.

The questionnaire includes closed-ended questions. In the first part of the questionnaire, there are questions to determine the demographic structure of the participants and whether they have knowledge about biophilic design. In the second part, the participants were asked questions about the integration of biophilic design elements into office designs. The participants were asked to read the statements prepared for office designs and evaluate them on a 5-point Likert scale according to their level of importance. On this scale, 1 means "not at all important" and 5 means "very important" (Appendix 1).

The questionnaire was conducted online between August 2021 and May 2022 via e-mail to the respondents.

6.4.2 Measurement of attention levels and current mood states

6.4.2.1 D2 Attention Test

As stated by Brickenkamp (1962); D2attention test is used to assess concentration by measuring accuracy in discriminating similar visual stimuli under time pressure. The test was developed in 1962 in Essen, Germany, and in 1981 Brickenkamp standardized the test and made it suitable for current use. The test is applicable to individuals between the ages of 9 and 60. The test form contains 14 rows of 658 figures, 47 in each row. These figures consist of the letters d and p, and there are one, two, three and four dots above and below some letters. The letters can be found in 16 different ways according to the number of dots in each row. The main objective of the test is to find the letter d with a total of two dots. In the test, 20 seconds are given for each line and the test lasts approximately 7-8 minutes. The test is scored with two different scoring types and six scores are obtained during the test period. These scores are TN (total number of figures marked), E1 (number of figures omitted), E2 (number of figures marked incorrectly), CP (total number of correct figures marked), TN-E (test performance) and E% (percentage of errors) (Pisalski et al., 2020).

- A high total number of ticks (TN) indicates participants' selective attention skills, attentional continuity, high motivation and psychomotor speed.
- The E1 value indicates a low level of selective attention and performance deficits.
- The E2 value indicates excessive error making, specific learning disabilities, mental retardation, inattention, difficulty adapting to instructions and problems with visual discrimination.
- The TN-E value and a high TN-E value indicate the quality of the participant's performance and the balance between psychomotor speed and selective attention.
- The CP value assesses the stability of psychomotor speed and the quality of overall test performance.

- The FR value indicates low motivation and unstable psychomotor speed.

The adaptation of the test to Turkey and safety and validity studies in the norm and 11-14 age range were conducted by Toker in 1993. Çağlar (2003) determined its reliability and validity by using 706 Turkish athletes as a sample. The D2 attention test is reliable and can be used in studies to be conducted in Turkey (Yaycı, 2013) (Appendix C).

6.4.2.2 State Anxiety Scale (STAI)

The inventory, developed by C.D. Spielberger, R.L. Gorsuch, and R.E. Lushene in 1970, measures state and trait anxiety. The inventory contains two separate scales, each consisting of 20 items. It is adapted into Turkish by N. Öner and Le Compte in 1976. Since the aim of this study is to determine how the individual feels at a specific moment and under certain conditions, the state anxiety scale is used. The scale is a four-point Likert-type scale, scored as “1: not at all”, “2: a little”, “3: a lot”, and “4: completely”, and consists of 20 questions. The highest possible score is 80, and the lowest is 20. A higher score obtained from the scale indicates a higher level of anxiety (stress). The re-reliability of the scale is found to be 0.76 (Öner, 1997; Özgüven, 1999) (Appendix D).

6.4.3 Measurement of physiological parameters

6.4.3.1 Blood pressure, pulse, body temperature, partial oxygen pressure

Anxiety levels are correlated with physiological responses such as blood pressure, heart rate, and respiration. Elevated anxiety can lead to increased blood pressure, heightened heart rate, and changes in respiratory patterns. When the anxiety level of individuals increases, blood pressure, heart rate and respiratory rate increase (Şahin, 2019).

A study of pre-operative patients finds a significant correlation between anxiety levels and both systolic and diastolic blood pressure, suggesting that higher anxiety leads to increased blood pressure (Nabillah et al., 2023). In another study, individuals with moderate to severe anxiety experience larger declines in blood pressure during slow breathing exercises compared to those with low levels of anxiety (Howse et al., 2022).

Research using portable devices reveals that anxiety-induced states significantly alter heart rate variability (HRV) and respiratory rate variability (BRV), with certain biomarkers indicating high anxiety (Ritsert et al., 2022). Furthermore, a study conducted during magnetic resonance imaging (MRI) scans shows that anxiety and claustrophobia significantly affect systolic blood pressure, but the changes in heart rate are not statistically significant (Al-Shimmery & Raheem, 2022).

6.4.3.2 Cortisol hormone

Cortisol is a steroid hormone produced by the adrenal cortex (Fukuda & Morimoto, 2001). As a physiological response to mood changes such as stress and anxiety, cortisol hormone levels increase in the body. Cortisol hormone is measured in three ways: serum total cortisol measurement, plasma free cortisol measurement, and salivary cortisol measurement. Salivary cortisol measurement, which is used increasingly in scientific studies, serves as an alternative to plasma free cortisol measurement due to its ease of collection without vascular access and its advantage of being less affected by stress factors. The hormone cortisol is bioactive in saliva, and there is a balance between salivary cortisol and free cortisol, independent of the amount of saliva. Instantaneous changes in free cortisol are reflected in the salivary cortisol concentration within a few minutes. Accordingly, the level of cortisol in saliva and the level of free cortisol in plasma (blood), obtained from an instantaneous sample over a period of 2-3 minutes, remain consistent (Filiz Araz, 2011).

6.4.4 Measurement of EEG datas

Electroencephalography (EEG) is one of the most common techniques for non-invasively studying the electrical activity of the brain by measuring electrical potential changes related to brain function through electrodes placed on the scalp. EEG records the spatial distribution and temporal variations of voltage fields, capturing various brain activities that occur with the neural transmission of electrical discharges propagating volumetrically on the surface of the brain, thus providing real-time analysis of neural processes (Marino & Mantini, 2024; Parbat & Chakraborty, 2021).

EEG is used in the diagnosis and surgical planning of epilepsy, sleep disorders, and brain tumors; it also has an important function in the recognition of mental illnesses

such as depression and the identification of emotional states (Anis et al., 2023; Parashar, 2023; Ruchika et al., 2023).

In this study, typical EEG data, non-linear features and time features were used.

6.4.5 Preparation and implementation of the experiment

According to the results of the frequency analysis of the expert surveys conducted within the scope of the study, biophilic design elements with an average value of 3 and above were integrated into the biophilic office design. These designs were modeled in three dimensions with 3Dmax software and visualized panoramically using the V-ray rendering engine, suitable for VR experience. The office design with biophilic design elements is presented in Figure 6.6 with a panoramic view, and the office design without biophilic design elements is presented in Figure 6.7, also panoramic. Both office environments measure 4x7 meters and are designed in the same layout (Figure 8-9). When designing the office with biophilic elements, care was taken to ensure that each biophilic element was equally dominant (Figure 6.10). In the non-biophilic office design, a minimalist and modern design language was adopted and natural elements (e.g. materials, plants, etc.) were not included (Figure 6.11).



Figure 6.6 Panoromic render of biophilic office design



Figure 6.7 Panoromic render of non-biophilic office design



Figure 6.8 Layout of biophilic office design



Figure 6.9 Layout of non- biophilic office design



Figure 6.10 Biophilic office design



Figure 6.11 Non-biophilic office design

The experiment was conducted at Izmir Katip Çelebi University, Faculty of Engineering and Architecture between January 14, 2023 and February 27, 2023. The environment in which the experiment was conducted was specifically chosen as an area designed to not restrict the freedom of movement of the participants, dominated by neutral colors and free of distractions. This space was chosen to ensure that the participants were not affected by environmental factors during the experiment and that the experimental conditions could be provided in a standardized manner (Figure 6.12).



Figure 6.12 Experimental Enviroment

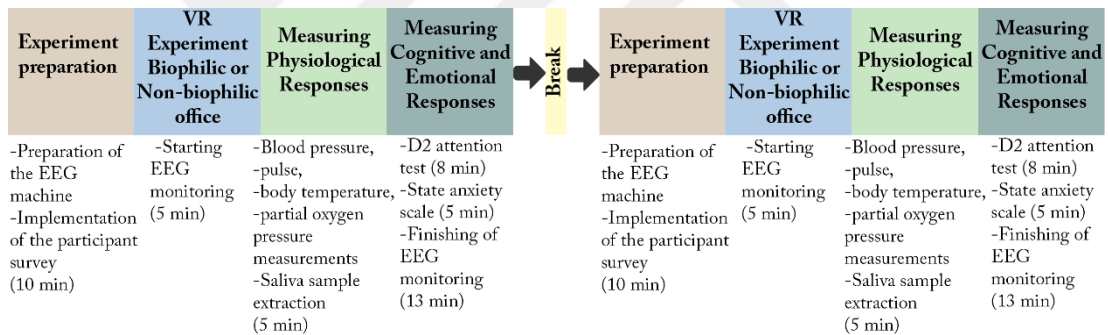


Figure 6.13 Experiment steps

Figure 6.13 describes the experimental stages of the study in detail. In the first stage, participants' demographic information was collected and it was verified that they met the inclusion criteria. At the same time, an informed consent form was signed by the participants confirming their voluntary participation in the experiment. Then, the EEG device was attached to the participants. EEG (Electroencephalography) allows the measurement of electrical activity resulting from communication between brain neurons through electrodes placed on the scalp. In this study, EEG signals of 30 participants were recorded from 14 different EEG channels (AF3, F7, F3, FC5, T7, P7, O1, O2, P8, T8, FC6, F4, F8, AF4) at a sampling frequency of 256 Hz using an Emotiv Epoc recorder. Figure 6.14 shows the position of the electrodes placed on the scalp during EEG measurement and the positioning of the EEG machine.

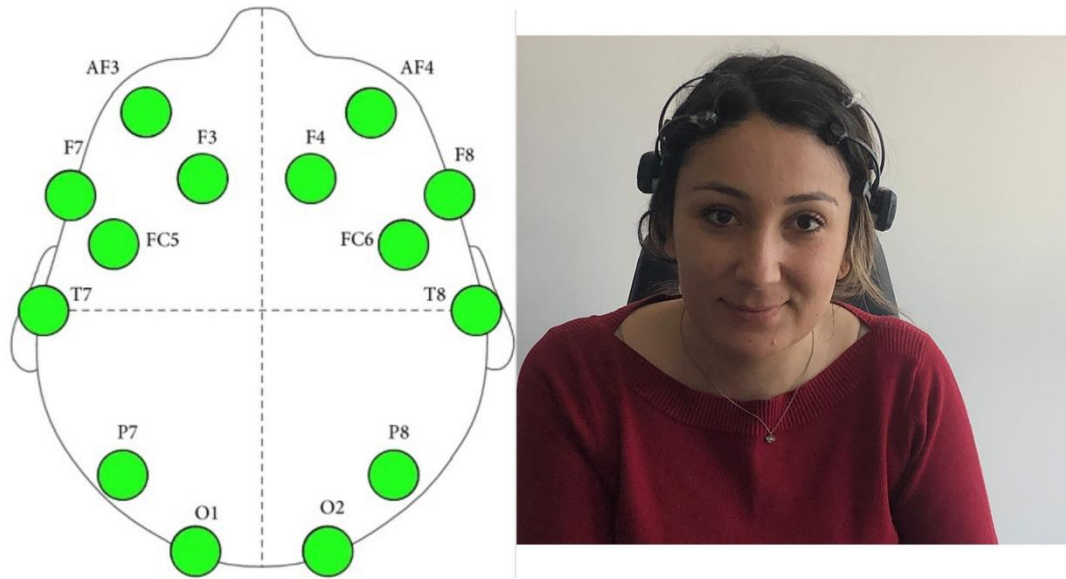


Figure 6.14 EEG layout

Then, the VR headset was placed on the EEG device for the participants (Figure 6.15)



Figure 6.15 Layout of VR and EEG devices

After the VR headset and EEG device were placed on the participants, the VR experience was started and the participants were allowed to move comfortably and at a level that would not affect the EEG signal quality. The connections of the EEG headset were checked and EEG monitoring was started. The VR experience lasted 5 minutes (Figure 6.16).



Figure 6.16 VR experience

After the VR experience was completed, EEG monitoring was turned off and physiological parameters such as blood pressure, pulse rate (beats/min), respiratory rate (min), body temperature (C°) and partial oxygen pressure (mmHg) were measured. In addition, saliva samples were collected to determine salivary cortisol levels (Figure 6.17). The data obtained were recorded on the experiment form.



Figure 6.17 Measurement of physical data

After the physical data were measured, the State Anxiety Scale and D2 attention test were administered to measure the stress and attention levels of the participants. These tests were completed in approximately 13 minutes (Figure 6.18).



Figure 6.18 Measurement of anxiety and attention data

Each participant was exposed to two different virtual office environments with and without biophilic design elements using the same procedures. In order to be able to compare the effects of both environments, the experiment was cross-applied so that participants experienced the two designs in different orders. This approach was chosen to minimize the impact of any ordering effect on the results.

6.5 Data analysis

The analysis of the data was divided into two categories: the analysis of the questionnaire data and the analysis of the experimental data.

6.5.1 Analysis of survey data

Data were analyzed using IBM SPSS (Statistical Package for the Social Sciences) 26.0 software. First, frequency analysis was conducted to assess the demographic characteristics of the participants and the distribution of their responses to the survey questions. This analysis explores participants' demographic information, including age, gender, and occupation, along with their general perspectives on biophilic design elements. To determine if the data followed a normal distribution, Kolmogorov-Smirnov and Shapiro-Wilk tests were conducted. When the assumption of normal distribution was not satisfied, nonparametric tests were utilized. Mann-Whitney U test

was used to analyze the differences between paired groups and Kruskal-Wallis H test was used to examine the differences between three or more groups.

6.5.2 Analysis of experimental data

6.5.2.1 Analysis of EEG data

EEG is a technique that measures the electrical activity caused by brain neurons communicating with each other and this measurement is performed through electrodes placed on the scalp. In the proposed study, an Emotiv Epoc-X recorder was used to record EEG signals from 30 participants over 14 EEG channels (AF3, F7, F3, FC5, T7, P7, O1, O2, P8, T8, FC6, F4, F8, AF4) with a sampling frequency of 256 Hz. EEG signals were recorded in two different environments, both with and without biophilic design elements. In the preprocessing stage, a Butterworth Type II band-pass filter ([0.5-48] Hz passband) was applied to the EEG signals to remove 50 Hz power line noise and other interferences caused by blinking and muscle movements of the participants. The Butterworth filter is a type of filter that has a monotonic frequency response in both stop and passband. This filter is defined by its order (n) and cutoff frequency (ω_c). The frequency response of the Butterworth filter is expressed as follows (Bogdan & Panu, 2015; Thakur et al., 2018).

$$[H(j\omega)] = \frac{1}{1 + \left[\frac{\omega}{\omega_c}\right]^2} \quad (6.2)$$

Within the scope of the experiment, all analyses were performed on 5-second EEG segments obtained from each participant. Within the scope of these analyses, time domain features, spectral features and non-linear features were calculated from EEG signals.

- Typical EEG data

The amplitudes of EEG signals recorded on the scalp are usually measured at the microvolt (μV) level, and these amplitudes can vary depending on factors such as environmental noise, age, and brain activity. EEG signals are located in the low

frequency range of 0.5-100 Hz. Research has shown that different brain activities and physical conditions affect specific sub-bands of this broad frequency band (Figure 6.19). Different names have been used to distinguish these sub-bands: delta (δ), theta (θ), alpha (α), beta (β) and gamma (γ) (Eroğlu, 2020).

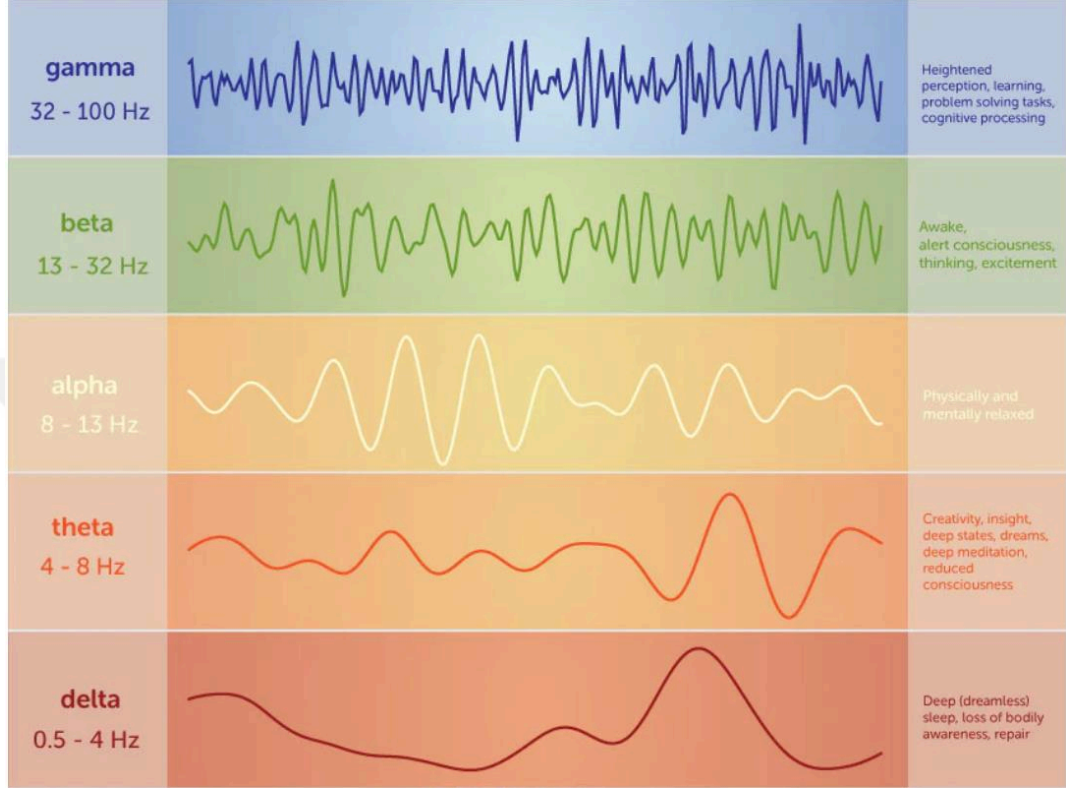


Figure 6.19 delta (δ), teta (θ), alfa (α), beta (β) ve gama (γ) frequencies of waves
(Muse head bant, 2025.)

The conversion of EEG data to image format only after preprocessing can lead to highly complex images. This can negatively affect the accuracy of the model to be used for classification. Various feature extraction methods are available for efficient representation of EEG signals. One of these methods is the Welch power spectral density estimation, which provides a more accurate and smoother analysis of the frequency components of the signals (Özcan & Çızmecı, 2020).

The power distribution of EEG signals in the frequency domain was described by the Power Spectral Density (PSD) function. The PSD of each 5-second EEG segment was calculated using the Welch method.

The Welch method is a process consisting of four basic steps. First, the signal is divided into overlapping segments. Then, each segment is windowed to smooth the edges of the segments and reduce possible edge effects. In the third step, a periodogram is calculated for each windowed segment and an estimate is made by averaging these periodograms. In the last step, the Welch method obtains the power spectral density by averaging the improved periodograms. In this process, the i 'th improved periodogram forms the basis of the calculations. The i 'th improved periodogram is expressed as follows.

$$\hat{S}_{xx}^i(f) = \frac{Y_s}{K \cdot M} a_0 \left| \sum_{n=1}^{M-1} x_i(n) w(n) e^{-j2\pi^2 \Pi} \right|^2 \quad (6.3)$$

Where $f = f_s$ is the normalized frequency variable, Y_s is the scaling factor, $w(n)$ is the windowing function and K is the normalizing constant, and are shown below.

$$K = \frac{1}{M} \sum_{n=1}^{M-1} w^2(n) \quad (6.4)$$

Welch method power spectral density estimation is shown below L is the length of the sign (Türk et al., 2015).

$$\hat{P}_w(f) = \frac{1}{L} \sum_{i=0}^{L-1} \hat{S}_{xx}^i(f) \quad (6.5)$$

The spectral data obtained by this method are described below.

Gamma waves are in the frequency range of 32 Hz. and above. Gamma waves are very weak signals and usually occur during conscious perception. High gamma activity is thought to be an indicator of some neurological disorders (Hemeida & Mostafa, 2017; Hughes, 2008).

Beta waves are recorded as low amplitude EEG signals in the frequency range of 12 to 32 Hz. These waves are predominant during mental activities such as alertness, deep thinking, careful focusing and problem solving. It is also noted that high levels of beta waves may be associated with panic states. Beta waves are small and fast signals that are directly related to focused attention. An increase in beta activity is observed especially during resistance to movement, suppression or solving a mathematical problem. When gamma and beta waves increase together, it indicates a strong connection with concentration (Dustman et al., 1962; Hemeida & Mostafa, 2017).

Alpha waves usually occur in the posterior regions of the brain and are observed in the frequency range of 8-13 Hz. These waves have a sinusoidal structure and become dominant in states of physical and mental relaxation. It is known that alpha waves are especially intense in a relaxed state that does not require attention and concentration. Alpha waves are most frequently recorded when the eyes are closed and the person is in a state of calm waiting. The most dominant sub-band in adult brain activity is usually the alpha band. Also, focusing on peaceful thoughts with eyes closed contributes to an increase in alpha waves (Hemeida & Mostafa, 2017; Toscani et al., 2010). Increased anxiety can be characterized by decreased alpha brain wave activity (Paszkiel et al., 2020).

Theta waves are found in the frequency range of 4 to 8 Hz. and are often associated with inefficiency, daydreaming. These waves are observed at their lowest levels during transitions of consciousness, representing the fine line between wakefulness and sleep. An increase of theta waves can occur as a result of emotional stress and is also linked to states of creative inspiration and deep meditation. Theta waves become predominant especially during the transition from consciousness to sleep or contemplative state, light sleep, meditation, relaxation and emotional relaxation. The theta band, recorded as the most dominant band in EEG signals during childhood, is also one of the most prominent EEG sub-bands in studies on emotional state (Hemeida & Mostafa, 2017; Schacter, 1977).

Delta waves, ranging from 0.5 to 4 Hz., are the slowest waves and occur during sleep. These waves are most often associated with deep sleep. However, some research has shown that delta waves can also be active during cognitive activities that require focus and attention. In particular, delta waves, which have been observed as a dominant band

in the brain activity of infants, contribute to important brain processes that occur during sleep (Amzica & Steriade, 1998; Hemeida & Mostafa, 2017).

Then the total power of the EEG signals in the whole frequency range was calculated. The total power S_T was calculated by summing the power spectral density in all frequency bands (delta, theta, alpha, beta, gamma) using the Discrete Fourier Transform (DFT) and periodogram method. The total power is calculated as follows (Cura et al., 2022; Cura & Akan, 2021).

$$S_T = \sum_{k=0}^{N-1} S(w_k) \quad (6.6)$$

$S(w_k)$ represents the power at each frequency segment.

Higher order spectral moments were also calculated in the study. These are statistical measures that describe the distribution of a signal in the frequency spectrum. Accordingly;

Moment 1 (Average): The weighted average frequency of the signal. It can also be defined as the frequencies that add the most to the signal.

Moment 2 (Variance): Measures how widely the frequencies of the signal are spread. A high moment 2 value indicates that the energy of the signal is distributed over a wide frequency range.

Moment 3 (Skewness): The Moment 3 value indicates whether the frequency of the signal is asymmetric. This value helps to understand on which side of the frequency spectrum the signal is concentrated.

The spectral moments (m_j) are calculated as follows:

$$M_j = \sum_{k=0}^{N-1} (w_k)^j S(w_k) \quad (6.7)$$

In the above formula $j=1,2,3$ represents the moment degree (Cura et al., 2022; Cura & Akan, 2021).

- Time Domain Features

Time domain features of EEG signals include various characteristics derived from both temporal and frequency components of brain activity. These features are of great importance for a deeper understanding of brain dynamics and for the identification of neurological disorders such as epilepsy. The analysis of EEG signals is based on the extraction of statistical features and the minimal loss of information in the signals analyzed by this method (Duda, 2023).

Energy: Energy is a widely known feature in the field of signal processing to determine and characterize the strength of a signal. For a signal of length N , energy calculations play an important role in determining the basic properties of the signal (Fasil & Rajesh, 2019).

$$x[n] = \{x[1], x[2], \dots, x[N]\} \quad (6.8)$$

$$E = \sum_{n=1}^N |x[n]|^2$$

Skewness: The skewness feature evaluates whether the probability distribution of a real-valued random variable is asymmetric with respect to its mean. A curve is considered skewed when it shifts left or right from the mean. The skewness of the signal ($x[n]$) is expressed by its length N and its mean (Kaliraman & Duhan, 2021; Karabiber Cura et al., 2020; Yu et al., 2022).

$$x[n] = \{x[1], x[2], \dots, x[N]\} \quad (6.9)$$

$$S = \frac{\frac{1}{N} \sum_{n=1}^N (x_n - \bar{X})^3}{\left(\sqrt{\frac{1}{N} \sum_{n=1}^N (x_n - \bar{X})^2} \right)^3}$$

Kurtosis: Kurtosis is defined as a statistical measure of the peak of a probability distribution. It is also a measure of the tail structure of the probability distribution. A signal ($x[n]$) is expressed by its length N and its mean (Kaliraman & Duhan, 2021; Karabiber Cura et al., 2020; Yu et al., 2022).

$$x[n] = \{x[1], x[2], \dots, x[x]\} \quad (6.10)$$

$$K = \frac{\frac{1}{N}(x_n - \bar{X})^4}{(\sqrt{\frac{1}{N}\sum_{n=1}^N(x_n - \bar{X})^2})^2}$$

Root Mean Square (RMS): The RMS value is the most important parameter describing the strength of the signal. The length of the signal N is expressed as the RMS value ($x[n]$) (Jones, 2018; Kaliraman & Duhan, 2021).

$$x[n] = \{x[1], x[2], \dots, x[N]\} \quad (6.11)$$

$$RMS = \sqrt{\frac{\sum_{n=1}^N(x_n)^2}{N}}$$

Peak to Peak (PTP): PTP is defined as the difference between the positive and negative amplitudes of a signal (Boonyakitanont et al., 2020; IEEE Instrumentation and Measurement Society, 2011).

$$PTP = X_{max} - X_{min} \quad (6.12)$$

Hjorth Parameters: Three Hjorth parameters are used to describe the spectral characteristics of EEG signals in the time domain (Yang et al., 2004).

These parameters are described below:

Activity: This parameter is used to determine the time variance of the signal strength.

$$Activity = var(x(t)) \quad (6.13)$$

Mobility: This parameter specifies the average frequency or standard deviation of the power spectrum (Yang et al., 2004).

$$Mobility = \frac{\sqrt{var\left(\frac{dx(t)}{dt}\right)}}{\sqrt{var(x(t))}} \quad (6.14)$$

Complexity: Bu parametre frekanstaki değişimi belirtir (Tawfik et al., 2016) .

$$Complexity = Mobility \cdot \frac{dx(t)}{dt} \cdot Mobility(xt) \quad (6.15)$$

Mean: The mean of a signal is a fundamental statistical measure obtained by dividing the sum of all values of the signal by the total number of values. In biomedical signals such as EEG, the mean value is used to determine the general trend or baseline activity level of the signal (Yang et al., 2004).

Mathematically, the mean of a signal is calculated as:

$$\mu = \frac{1}{N} \sum_{i=1}^N x_i \quad (6.16)$$

Where:

x_i is the i -th sample of the signal.

N is the total number of samples.

μ is the mean value of the signal.

Mean Absolute Deviation (MAD) is a measure of the variability or dispersion of a dataset. It represents the average absolute deviation of each data point from the mean of the dataset (Kaliraman & Duhan, 2021).

$$MAD = \frac{1}{N} \sum_{i=1}^N |x_i - \mu| \quad (6.17)$$

x_i is each individual data point,

μ is the mean of the dataset,

N is the total number of data points.

- Non-Linear Features

It is a method used to study complex and dynamic changes in EEG signals. This method reveals the complex structures underlying the signal by examining the irregular and chaotic behavior of cortical networks associated with brain electrical activity over time (Kutepov et al., 2020).

Chaos Analysis: This analysis is the process of detecting and quantifying chaotic phases from nonlinear time series. This analysis is an approach to understanding complex dynamic behavior by examining the sensitivity of the system to initial conditions. It is particularly used to better understand the complexity and irregularity of biological signals such as EEG (Jeong et al., 1998; van Drongelen, 2007).

In this study, Largest Lyapunov Exponent (LLE) and Correlation Dimension (CD) analyses were performed and explained below.

Largest Lyapunov Exponent (LLE): The LLE is used to calculate the average exponential rate at which the neighboring orbits of an attractor move away or closer together. The exponent in each dimension is denoted by λ_i , which expresses how the distance between two initially close orbits changes over time. A value of $\lambda_i > 0$ indicates that the orbits in that dimension are moving away from each other, while $\lambda_i < 0$ indicates that they are getting closer (van Drongelen, 2007; Zahra et al., 2017).

The calculation of the Lyapunov exponent analyzes the expansion over a given time interval along the major axis of an orbit. This analysis is usually performed theoretically with a specific formula and expressed by an exponential relationship of the form $e^{\lambda_i t}$. This relationship is an important tool in understanding the dynamical structure of the system and its chaotic behavior (van Drongelen, 2007)..

$$\lambda_i = \lim_{t \rightarrow \infty} \frac{1}{t} \log_2 \frac{p_i(t)}{p_i(0)} \quad (6.18)$$

In fact, these equations are not directly used in EEG analysis; therefore, Lyapunov exponents must be calculated on time series data. Usually only the Largest Lyapunov Exponent (LLE) is taken into account, because if this value is positive, the system is predicted to have a chaotic structure. Therefore, LLE is used as an important criterion to study chaotic behavior in EEG data (van Drongelen, 2007).

The calculation of the distance at the beginning (d_{i-1}) and at the end (d_i) is repeated k times in the time period between t_0 and t_k . The Largest Lyapunov Exponent (LLE, λ_{max}) is calculated as shown below. By analyzing how the initial proximity of the orbitals in the time series changes with time, this process allows the identification of chaotic features in the dynamical structure of the system (van Drongelen, 2007).

$$\lambda_{max} = \frac{1}{t_k - t_0} \sum_{i=1}^k \log_2 \frac{d_i}{d_{i-1}} \quad (6.19)$$

Correlation Dimension (CD): CD can indicate how flexible a time series is, but it can also assess the complexity and degrees of freedom of the system. If the correlation dimension is not an integer, the system is considered to have a chaotic structure. This metric is used as an important tool, especially in understanding the behavior and structural properties of dynamical systems (Kobayashi et al., 2001; Motamedi-Fakhr et al., 2014).

The Grassberger and Procaccia algorithm is used to numerically determine the correlation dimension (CD) for a time series. This algorithm proceeds through the

following three steps in the 1-D embedding space of a time series defined as $x = (x_1, x_2, \dots, x_n)$. These steps are an important way to study the chaotic and dynamic properties of the time series (Brari & Belghith, 2021).

$C(r)$ is the sum of the probabilities that two different pairs of points are closer than a given threshold value r . This probability is calculated by the following equation. This method plays a critical role in understanding the relationship between points in time series and the dynamic structure of the system.

$$C(r) = \sum_{i=1, i \neq j}^N (\Theta(r - \|x_i - x_j\|)) \quad (6.20)$$

Here Θ is defined as the Heaviside function and $\theta(x)$ is expressed as follows.

$$\Theta(x) = \begin{cases} 0, & x < 0 \\ 1, & x > 0 \end{cases} \quad (6.21)$$

This function is used to compare points with respect to a given threshold value r and is important in the dynamic analysis of the system.

The correlation integral C_r is expressed in the following equation. N is the length of the time series.

$$C_r = \lim_{N \rightarrow \infty} \frac{C(r)}{N^2} \quad (6.22)$$

CD is determined by estimating the slope of the log-log plot of C_r versus r in the linear region as r approaches zero. The correlation dimension is calculated from this slope and defined by Equation and is used as an important metric to understand the dynamic behavior of the system.

$$CD_r = \lim_{N \rightarrow \infty} \frac{\log(C_r)}{\log(r)} \quad (6.23)$$

Fractal analysis: The fractal dimension technique is an effective method used to quantify the geometric complexity of the signal. This technique is a valuable approach to assess the complexity of EEG signals. In general, more complex brain signals are thought to have higher information processing capacity compared to more predictable signals. A common view is that increased complexity and self-similarity in the signal is associated with higher Fractal Dimension values (K. Shen et al., 2021; Zahra et al., 2017).

In this study, Hurs Expoment (HE), Katz's Fractal Dimension, Higuchi Fractal Dimension values were calculated.

Hurs Expoment (HE): The HE value varies between 0 and 1. If HE is equal to 0.5, it indicates that there is no correlation in the time series. If the HE value is in the range $0 < HE < 1$, it indicates that the time series has long-range anti-correlations, while the range $0.5 < HE < 1$ is associated with the presence of long-range correlations. The HE value is calculated using the following equation (Karabiber Cura et al., 2020).

$$x[n] = \{x[1], x[2], \dots, x[N]\} \quad (6.24)$$

$$X_m[n] = \sum_{i=1}^n x[i] - \mu \quad n = 1, \dots, N$$

$$R[m] = \max(\{X_M[1], X_M[2], \dots, X_M[m]\}) - \min(\{X_M[1], X_M[2], \dots, X_M[m]\})$$

$$S[m] = \sqrt{1/m \sum_{k=1}^m (X[k] - \bar{X}_m)^2}, \quad m=1, \dots, N$$

$$LN = \ln \frac{R(a)}{S(a)} \quad a = 1, \dots, N$$

$X[n]$ describes the EEG signal and μ indicates the mean value of this signal. $x_M[n]$ denotes the cumulative deviation value of $x[n]$. $R[m]$ denotes the interval series and $S[m]$ denotes the standard deviation of the time series $x[n]$. x_m^- is the mean value from $X[1]$ to $X[m]$. HE is calculated as the slope of the line on which LN is plotted against $\ln_{(a)}$ (Karabiber Cura et al., 2020).

Katz's Fractal Dimension: According to Katz's method, the sum and average of the Euclidean distances between successive points of the sample (M and k respectively) are evaluated over the maximum distance (d) between the first point and any other point in the sample. The fractal dimension (D) of the sample is calculated as the following equation (Loo et al., 2011).

$$D = \frac{\log(\frac{M}{k})}{\log(\frac{d}{k})} = \frac{\log(n)}{\log(n) + \log(\frac{d}{M})} \quad (6.25)$$

Higuchi Fractal Dimension: HFD is used to calculate the fractal dimension directly from time series signals. One of the most important parameters in HFD calculation is the $k_{\max}$ value. The ideal value for the $k_{\max}$ parameter is obtained by plotting the HFD values calculated in a certain $k_{\max}$ range against this range. The k value at which the resulting curve reaches saturation is considered as $k_{\max}$ (Karabiber Cura et al., 2020).

$$x[n] = \{x[1], x[2], \dots, x[N]\} \quad (6.26)$$

$$X_k^a = \{X[a], X[a+k], X[a+2k] \dots, X[a + \text{int}(\cdot) * K]\}, \quad a = 1, 2, \dots, k.$$

$$L[a, k] = \frac{\{\sum_{i=1}^{\text{int}(\cdot)} |X[a+ik] - X[a+(i-1)k]| \} \frac{N-1}{\text{int}(\cdot)}}{k}$$

$$L[k] = \frac{1}{k} L[a, k], \quad a = 1, 2, \dots, k.$$

$X[n]$ is the one-dimensional time series and N is the length of the original signal. X_a represents the new time series. For the calculation of X_a , k and a are

integers and the $\text{int}(\cdot)$ operation takes the integer part of the expression $(N-M) \lfloor k$. $L[a,k]$ represents the size of the new time signals. The value of $L[k]$ is calculated by averaging $L[a,k]$. HFD is calculated as the slope of the line obtained by plotting $L[k]$ values against $\ln[1/k]$. Here $k=1,2,\dots, k_{\max}$ (Karabiber Cura et al., 2020).

Entropy Analysis: Entropy refers to the rate at which information is generated in dynamical systems. The term “high entropy” refers to the degree of complexity and unpredictability in a system (Jeong et al., 1998; Zahra et al., 2017).

Approximate Entropy (ApEn Entropy): ApEn is a widely used method. If signals are regularized, i.e. have a low degree of complexity, they are more likely to remain similar to each other in consecutive samples, indicating a low ApEn value (Jeong et al., 1998; Zahra et al., 2017).

The calculation of the ApEn Entropy value is given in the following formulas (Karabiber Cura et al., 2020).

Separation of an EEG signal consisting of N data points. The $N-m+1$ vector is defined as $X(1) \dots X(N-m+1)$.

$$X = \{X_1, X_2, \dots, X_N\} \quad (6.27)$$

The vector $N-m+1$ is defined as $X(1) \dots X(N-m+1)$.

$$X(i) = [X(i), X(i+1), \dots, X(i+m-1)] \quad (6.28)$$

The maximum norm distance between $X(i)$ and $X(j)$ is calculated as follows.

$$(6.29)$$

$$d[X(i), X(j)] = \max_{k=1,2,\dots,m} |X(i+k-1) - X(j+k-1)|$$

The vector $X(j)$ satisfying the condition $d[X(i), X(j)] \leq r$ when $i \neq j$ for $J=1, \dots, N-m+1$ is found by the following equation. The r in the equation refers to the comparison tolerance value. The number of vectors satisfying the conditions in the above equation is expressed as B_i and the probability of a similar pattern is expressed as follows.

$$C_r^m = \frac{B_i}{N - m + 1} \quad (6.30)$$

The mean of the natural logarithm is calculated by the following equation.

$$\theta^m(r) = \frac{1}{N - m + 1} \sum_{i=1}^{N-m+1} \ln C_r^m(i) \quad (6.31)$$

θ^{m+1} is calculated by increasing the size of the process shown in the above equation to $m+1$. The approximate entropy is found by the following equation using fixed values of m and r .

$$ApEn(m, r, N) = \theta^m(r) - \theta^{m+1}(r) \quad (6.32)$$

In this study, time domain, spectral and nonlinear features were calculated from a 5-second EEG segment. The calculated features were normalized in the range of 0-1 and the normalized features were imported into IBM SPSS Statistics 26.

6.5.2.2 Analysis of physiological data

During the experiment, blood pressure, pulse rate, body temperature and partial oxygen pressure data obtained from the participants were measured regularly and these measurements were transferred to SPSS software. In addition, saliva samples collected daily were sent to the laboratory for analysis of cortisol hormone levels, and the results were processed into the IBM SPSS Statistics 26 database after they were received from the laboratory.

6.5.2.3 Analysis of psychological data

The scores obtained from the State Anxiety Scale were manually calculated and recorded. Similarly, the D2 Attention Test was also analyzed by manual assessment method. The scores obtained from this test were analyzed in terms of the following variables: TN (total number of figures marked), E1 (number of skipped figures), E2 (number of incorrectly marked figures), CP (total number of correctly marked figures), TN-E (overall test performance) and E% (percentage of errors). After all these data were obtained, they were transferred to IBM SPSS Statistics 26 software for statistical analysis.

6.5.2.4 Statistical analysis

In this study, statistical analyses were performed using IBM SPSS Statistics 26 software. The analyses aimed to determine the significance of differences between physiological and psychological parameters and EEG data measured in biophilic and non-biophilic offices.

The statistical methods and tests used in the study are as follows:

Descriptive Statistics: Descriptive statistics such as means, standard deviations and percentages were calculated for all variables to summarize the demographic characteristics of the participants such as age, gender, marital status, educational status and occupation.

Paired Sample t-test: Paired sample t-tests were used to compare the means of physiological parameters (blood pressure, heart rate, body temperature, salivary cortisol levels and SpO₂) and D2 attention test scores (TN, E1, E2, TN-E, CP, FR) between biophilic and non-biophilic offices.

Wilcoxon Signed Rank Test: In order to compare nonparametric data, Wilcoxon Signed-Ranks Test was applied for State Anxiety Scale scores and some EEG features (nonlinearity and subband power).

EEG Data Analysis: EEG signals were processed using MATLAB 2023 software. Time domain, spectral and nonlinear features obtained from EEG signals were normalized between 0 and 1. Statistical comparisons of EEG features between biophilic and non-biophilic office N- environments were performed with paired sample t-test and Wilcoxon Signed Rank Test depending on the distribution of the data.

All statistical tests were performed at 5% significance level.

7 Findings

The findings obtained in this study are presented under two main headings: firstly, the findings based on the expert survey data; secondly, the findings related to the experimental phase.

7.1 Findings regarding expert survey data

How demographic and professional characteristics of the participants, such as their level of knowledge about biophilic design, gender, age, professional fields and whether they have postgraduate education or not, affect the degree of importance of these elements is investigated and the findings are presented in table 7.1

Table 7.1 Data based on demographic information on participants

		Total (N)	Percent (%)
Gender	Female	254	66,3
	Male	129	33,7
Age	22-29	164	42,8
	30-44	154	40,2
	45-59	44	11,5
	60+	21	5,5
Profession	Architect	278	72,6
	Landscape Arch.	28	7,3
	Interior Arch.	27	7,0
	Psychiatrist	22	5,7
	Psychologist	28	7,3
In addition to your specialization, have you received postgraduate education in your field?	Yes	216	56,4
	No	167	43,6
If yes, what level of postgraduate education did you receive?	Master Degree	120	54,8
	PhD.	99	45,2
I have got knowledge biophilic design	Yes	86	22,5
	Partially	122	31,9
	No	175	45,7

66.3% of the participants were female (n=254) and 33.7% were male (n=129), and the majority of the participants were female. In terms of age distribution, 42.8% (n=164) of the participants were between 22-29 years old, 40.2% (n=154) were between 30-44 years old, 11.5% (n=44) were between 45-59 years old and 5.5% (n=21) were 60 years old and above. When the occupational distribution was analysed, 72.6% (n=278) of the participants were architects, 7.3% (n=28) were landscape architects, 7.0% (n=27) were interior designers, 5.7% (n=22) were psychiatrists and 7.3% (n=28) were psychologists. While 56.4% (n=216) of the participants had postgraduate education, 43.6% (n=167) did not have postgraduate education. Of those with postgraduate education, 54.8% (n=120) had a master's degree and 45.2% (n=99) had a doctorate.

Regarding biophilic design knowledge, 22.5% (n=86) of the participants stated that they had knowledge, 31.9% (n=122) stated that they had partial knowledge and 45.7% (n=175) stated that they did not have any knowledge on this subject (Table 7.1).

Table 7.2 presents an analysis of the importance of biophilic design elements in office design, with mean and standard deviation values for each element.

Table 7.2 Evaluation of biophilic design elements in office designs according to their importance

	Mean*	Std. D.
Having a nature view	4.09	0.86
Finding an element that I can connect with/resembles with fire	2.57	1.13
Pyramid-shaped plants	2.69	1.08
Column-shaped plants	2.91	1.11
Round-shaped plants	3.10	1.09
Scattered -shaped plants	3.12	1.19
Rough textured plants	2.73	1.08
Medium textured plants	2.94	1.03
Fine textured plants	3.08	1.05
Large sized plants	3.32	1.20
Medium sized plants	3.35	1.02
Small sized plants	3.37	1.11
Green-leaved (monochrome) plants	3.84	1.05
Multi-colored leafy plants	3.54	1.09
Flowering plants	3.54	1.19
Pet presence	2.99	1.37
Presence of a design element to evoke water	3.62	1.20
Using natural materials (wood, marble, etc.) that change over time	4.26	0.85
The use of color tones such as soil, green, blue, which reminds of nature	4.06	1.02
Using materials such as mirrors that reflect light	3.49	1.25
Getting sunlight	4.89	0.41
Using spiral forms	2.80	1.13
Using oval and round forms	3.08	1.15
Using organic forms	3.41	1.22
Existence of patterns created by abstraction of animate and inanimate beings/shapes in nature	3.13	1.16
Using fractal (snowflake, leaf, cone) patterns found in nature	3.01	1.15
Using contrasts that complement each other (such as using light and dark colors together)	3.81	1.08
Natural landscape painting presence	2.99	1.25
Presence of pictures of living things in nature	2.74	1.18
Presence of objects depicting living things in nature (bird, tree, seashell)	3.12	1.17

According to the findings in Table 7.2, among the elements evaluated by the participants with the highest averages, sunlight (mean = 4,89), the use of natural materials (wood, marble, etc.) (mean = 4,26) and the use of colour tones such as earth, green and blue (mean = 4,06), which remind of nature, stand out. In addition, having a view of nature (mean = 4,09) was also seen as an important feature by the participants. On the other hand, the elements with the lowest means were finding an

element associated with fire (mean = 2.57), pyramid-shaped plants (mean = 2.69) and the presence of living objects representing nature (mean = 2.74).

The normality analysis of the survey is presented in table 7.3

Table 7.3 Tests of Normality

	Tests of Normality					
	Kolmogorov-Smirnov ^a			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Having a nature view	0.300	383	0<.001	0.773	383	0<.001
Finding an element that I can connect with/resembles with fire	0.178	383	0<.001	0.902	383	0<.001
Pyramid-shaped plants	0.228	383	0<.001	0.892	383	0<.001
Column-shaped plants	0.233	383	0<.001	0.886	383	0<.001
Round-shaped plants	0.211	383	0<.001	0.893	383	0<.001
Scattered -shaped plants	0.210	383	0<.001	0.900	383	0<.001
Rough textured plants	0.206	383	0<.001	0.906	383	0<.001
Medium textured plants	0.243	383	0<.001	0.885	383	0<.001
Fine textured plants	0.218	383	0<.001	0.897	383	0<.001
Large sized plants	0.256	383	0<.001	0.881	383	0<.001
Medium sized plants	0.271	383	0<.001	0.849	383	0<.001
Small sized plants	0.247	383	0<.001	0.878	383	0<.001
Green-leaved (monochrome) plants	0.259	383	0<.001	0.846	383	0<.001
Multi-colored leafy plants	0.238	383	0<.001	0.882	383	0<.001
Flowering plants	0.214	383	0<.001	0.887	383	0<.001
Pet presence	0.168	383	0<.001	0.890	383	0<.001
Presence of a design element to evoke water	0.257	383	0<.001	0.862	383	0<.001
Using natural materials (wood, marble, etc.) that change over time	0.271	383	0<.001	0.777	383	0<.001
The use of color tones such as soil, green, blue, which reminds of nature	0.282	383	0<.001	0.790	383	0<.001
Using materials such as mirrors that reflect light	0.250	383	0<.001	0.871	383	0<.001
Getting sunlight	0.519	383	0<.001	0.298	383	0<.001
Using spiral forms	0.216	383	0<.001	0.905	383	0<.001
Using oval and round forms	0.194	383	0<.001	0.900	383	0<.001
Using organic forms	0.233	383	0<.001	0.884	383	0<.001
Existence of patterns created by abstraction of animate and inanimate beings/shapes in nature	0.188	383	0<.001	0.905	383	0<.001
Using fractal (snowflake, leaf, cone) patterns found in nature	0.186	383	0<.001	0.913	383	0<.001
Using contrasts that complement each other (such as using light and dark colors together)	0.282	383	0<.001	0.838	383	0<.001
Natural landscape painting presence	0.187	383	0<.001	0.901	383	0<.001
Presence of pictures of living things in nature	0.186	383	0<.001	0.904	383	0<.001
Presence of objects depicting living things in nature (bird, tree, seashell)	0.205	383	0<.001	0.898	383	0<.001

‘Kolmogorov-Smirnov and Shapiro-Wilk Test’ was performed to test whether the data set was normally distributed. As a result of the analysis, it was seen that the data set did not conform to the normal distribution as a result of both normal distribution tests ($p < 0.05$). Therefore, nonparametric tests were used in the analyses. While analysing the questionnaire study, ‘Mann-Whitney U Test’ was used for pairwise comparisons and ‘Kruskal-Wallis H Test’ was used for comparisons of more than two variables (Table 7.3).

Table 7.4 presents the findings on the evaluation of biophilic design elements in office designs based on their importance according to gender. The table includes the mean scores, z-values, Mann-Whitney U test results, and significance values for each design element, highlighting gender-based differences.

Table 7.4 Data based on the evaluation of biophilic design elements according to the importance of the participants in office designs according to gender

		N	Mean	z	Mann-Whitney U	Sig
Having a nature view	Female	255	4.16	-1.476	15011.500	0.140
	Male	129	3.96			
Finding an element that I can connect with/resembles with fire	Female	255	2.46	-2.718	13685.000	0.007
	Male	129	2.78			
Pyramid-shaped plants	Female	255	2.77	-2.065	14352.500	0.039
	Male	129	2.52			
Column-shaped plants	Female	255	3.00	-2.187	14237.500	0.029
	Male	129	2.74			
Round-shaped plants	Female	255	3.20	-2.607	13827.500	0.009
	Male	129	2.90			
Scattered -shaped plants	Female	255	3.16	-0.846	15545.500	0.398
	Male	129	3.04			
Rough textured plants	Female	255	2.82	-1.996	14415.000	0.046
	Male	129	2.57			
Medium textured plants	Female	255	3.01	-1.726	14703.000	0.084
	Male	129	2.81			
Fine textured plants	Female	255	3.14	-1.546	14871.500	0.122
	Male	129	2.95			
Large sized plants	Female	255	3.47	-3.508	12939.000	0.000
	Male	129	3.02			
Medium sized plants	Female	255	3.49	-3.312	13211.000	0.001
	Male	129	3.07			
Small sized plants	Female	255	3.46	-2.068	14366.500	0.039
	Male	129	3.19			
Green-leaved (monochrome) plants	Female	255	4.02	-4.077	12423.500	0.000
	Male	129	3.49			
Multi-colored leafy plants	Female	255	3.60	-1.069	15336.000	0.285
	Male	129	3.41			
Flowering plants	Female	255	3.56	-0.006	16377.500	0.996
	Male	129	3.50			
Pet presence	Female	255	3.11	-2.564	13820.000	0.010
	Male	129	2.74			
Presence of a design element to evoke water	Female	255	3.67	-0.902	15496.500	0.367
	Male	129	3.52			
Using natural materials (wood, marble, etc.) that change over time	Female	255	4.28	-1.134	15316.500	0.257
	Male	129	4.21			
The use of color tones such as soil, green, blue, which reminds of nature	Female	255	4.19	-3.132	13395.000	0.002
	Male	129	3.81			
Using materials such as mirrors that reflect light	Female	255	3.64	-2.841	13579.500	0.004
	Male	129	3.20			
Getting sunlight	Female	255	4.93	-3.224	14755.500	0.001
	Male	129	4.81			
Using spiral forms	Female	255	2.85	-0.895	15503.000	0.371
	Male	129	2.72			
Using oval and round forms	Female	255	3.19	-2.328	14084.500	0.020
	Male	129	2.86			
Using organic forms	Female	255	3.50	-1.622	14779.000	0.105
	Male	129	3.23			
Existence of patterns created by abstraction of animate and inanimate beings/shapes in nature	Female	255	3.20	-1.650	14752.000	0.099
	Male	129	2.98			
Using fractal (snowflake, leaf, cone) patterns found in nature	Female	255	3.06	-0.997	15396.500	0.319
	Male	129	2.93			
Using contrasts that complement each other (such as using light and dark colors together)	Female	255	3.85	-0.827	15583.500	0.408
	Male	129	3.74			
Natural landscape painting presence	Female	255	3.10	-2.363	14030.000	0.018
	Male	129	2.77			
Presence of pictures of living things in nature	Female	255	2.78	-0.800	15588.500	0.424
	Male	129	2.68			
Presence of objects depicting living things in nature (bird, tree, seashell)	Female	255	3.14	-0.340	16047.000	0.734
	Male	129	3.09			

* Statistically significant at $p < 0.05$

When the statistical difference between the degree of importance of biophilic design elements in office designs between female and male participants is analysed; while

women found the expression ‘Having elements that I can connect with fire / evoke fire’ as less important with an average of 2,46, men found it very important with an average of 2,78. While women emphasised the importance of ‘Pyramid-shaped plants’ with a mean of 2.77, men stated that it was less important with a mean of 2.52. Women emphasised the importance of ‘columnar plants’ in biophilic office designs with a mean of 3,00, while men emphasised it as less important with a mean of 2,74. The presence of ‘round-shaped plants’ was more important for women with a mean of 3,20, while it was less important for men with a mean of 2,90. ‘Coarse textured plants’ is more important for women with a mean of 2,82 and less important for men with a mean of 2,57. When the importance level of the presence of ‘large, medium and small sized plants’ in biophilic office designs is examined according to gender, it is found that women find it more important with a mean of 3,47, 3,49 and 3,46 respectively, while men find it less important with a mean of 3,02, 3,07 and 3,19 respectively. The statement ‘Plants with green leaves (single colour)’ was found more important by women with a mean of 4.02, while men found it less important with a mean of 3.49. While women found the statement ‘Having pets’ more important with a mean of 3,11, men found it less important with a mean of 2,74. While women found the expression ‘Using colour tones such as earth, green, blue that reminds of nature’ more important with a mean of 4,19, men found it less important with a mean of 3,81. Female participants found the expression ‘Using materials that reflect light’ more important with an average of 3,64, while male participants found it less important with an average of 3,20. ‘Daylighting’ is considered very important in biophilic office designs by women with an average of 4,93, while men consider it less important with an average of 4,81. ‘Use of oval and round forms’ is more important for women with an average of 3,19, while it is less important for men with an average of 2,86. ‘Natural landscape painting presence’ is more important for women with an average of 3,10, while it is less important for men with an average of 2,77. (Table 7.4)

Table 7.5 presents the evaluations of the participants in different age groups regarding the importance of biophilic elements in office designs, and examines the significance of the differences between the groups with the “Kruskal-Wallis H Test”. The analysis statistically evaluates whether each biophilic element differs between age groups.

Table 7.5 Data based on the evaluation of the biophilic design elements in office designs according to the importance of the participants according to age

		N	Mean	Kruskal- Wallis H Test	Sig
Having a nature view	22-29	164	4.09	3.440	0.329
	30-44	155	4.05		
	45-59	44	4.23		
	60+	21	4.24		
Finding an element that I can connect with/resembles with fire	22-29	164	2.63	3.763	0.288
	30-44	155	2.45		
	45-59	44	2.73		
	60+	21	2.71		
Pyramid-shaped plants	22-29	164	2.79	6.586	0.086
	30-44	155	2.52		
	45-59	44	2.84		
	60+	21	2.86		
Column-shaped plants	22-29	164	3.07	6.472	0.091
	30-44	155	2.78		
	45-59	44	2.89		
	60+	21	2.76		
Round-shaped plants	22-29	164	3.21	2.612	0.455
	30-44	155	2.99		
	45-59	44	3.14		
	60+	21	3.05		
Scattered -shaped plants	22-29	164	3.07	3.482	0.323
	30-44	155	3.07		
	45-59	44	3.36		
	60+	21	3.38		
Rough textured plants	22-29	164	2.76	2.555	0.466
	30-44	155	2.65		
	45-59	44	2.91		
	60+	21	2.86		
Medium textured plants	22-29	164	3.05	4.775	0.189
	30-44	155	2.81		
	45-59	44	3.09		
	60+	21	2.81		
Fine textured plants	22-29	164	3.09	4.352	0.226
	30-44	155	2.99		
	45-59	44	3.34		
	60+	21	3.00		
Large sized plants	22-29	164	3.28	3.497	0.321
	30-44	155	3.35		
	45-59	44	3.50		
	60+	21	3.00		
Medium sized plants	22-29	164	3.41	2.486	0.478
	30-44	155	3.32		
	45-59	44	3.36		
	60+	21	3.05		
Small sized plants	22-29	164	3.42	1.610	0.657
	30-44	155	3.31		
	45-59	44	3.48		
	60+	21	3.19		
Green-leaved (monochrome) plants	22-29	164	3.83	2.183	0.535
	30-44	155	3.83		
	45-59	44	4.05		
	60+	21	3.62		
Multi-colored leafy plants	22-29	164	3.44	5.441	0.142
	30-44	155	3.55		
	45-59	44	3.84		
	60+	21	3.62		

Table 7.5 (continued)

Flowering plants	22-29	164	3.37	11.072	0.011
	30-44	155	3.55		
	45-59	44	3.91		
	60+	21	4.00		
Pet presence	22-29	164	3.17	4.691	0.196
	30-44	155	2.86		
	45-59	44	2.84		
	60+	21	2.81		
Presence of a design element to evoke water	22-29	164	3.70	1.759	0.624
	30-44	155	3.54		
	45-59	44	3.68		
	60+	21	3.57		
Using natural materials (wood, marbl., etc.) that change over time	22-29	164	4.24	0.671	0.880
	30-44	155	4.25		
	45-59	44	4.36		
	60+	21	4.29		
use of color tones such as soil, green, blue, which reminds of nature	22-29	164	4.02	2.890	0.409
	30-44	155	4.05		
	45-59	44	4.16		
	60+	21	4.24		
Using materials such as mirrors that reflect light	22-29	164	3.64	5.037	0.169
	30-44	155	3.42		
	45-59	44	3.41		
	60+	21	3.05		
Getting sunlight	22-29	164	4.85	4.189	0.242
	30-44	155	4.92		
	45-59	44	4.91		
	60+	21	4.86		
Using spiral forms	22-29	164	2.80	2.335	0.506
	30-44	155	2.73		
	45-59	44	2.91		
	60+	21	3.05		
Using oval and round forms	22-29	164	3.13	4.028	0.258
	30-44	155	2.96		
	45-59	44	3.23		
	60+	21	3.24		
Using organic forms	22-29	164	3.39	1.768	0.622
	30-44	155	3.40		
	45-59	44	3.61		
	60+	21	3.24		
Existence of patterns created by abstraction of animate and inanimate beings/shapes in nature	22-29	164	3.18	3.982	0.263
	30-44	155	3.03		
	45-59	44	3.34		
	60+	21	3.05		
Using fractal (snowflak, leaf, cone) patterns found in nature	22-29	164	2.91	3.243	0.356
	30-44	155	3.05		
	45-59	44	3.09		
	60+	21	3.29		
Using contrasts that complement each other (such as using light and dark colors together)	22-29	164	3.78	3.538	0.316
	30-44	155	3.83		
	45-59	44	4.05		
	60+	21	3.43		
Natural landscape painting presence	22-29	164	2.96	1.448	0.694
	30-44	155	2.95		
	45-59	44	3.16		
	60+	21	3.10		
Presence of pictures of living things in nature	22-29	164	2.68	6.605	0.086
	30-44	155	2.68		
	45-59	44	3.00		
	60+	21	3.19		
Presence of objects depicting living things in nature (bird, tree, seashell)	22-29	164	3.13	7.219	0.065
	30-44	155	2.98		
	45-59	44	3.45		
	60+	21	3.29		

* Statistically significant at $p < 0.05$

Participants over the age of 60 stated that the presence of 'flowering plants' was very important in biophilic office designs, with an average of 4, while those in the age group of 22-29 stated that it was less important with an average of 3.37 (Table 7.5).

The table below shows the importance given by occupational groups to biophilic elements in office designs and the statistical differences between them. Differences were evaluated with the “Kruskal-Wallis H Test” (Table 7.6).

Table 7.6 Data based on the evaluation of biophilic design elements in office designs according to the degree of importance according to the field of expertise of the participants

	N	Mean	Kruskal - Wallis H T.	Sig	N
Having a nature view	Architect	278	4.08	8.765	0.067
	Landscape A	28	4.39		
	Interior A	27	3.89		
	Psychiatrist	22	4.32		
	Psychologist	28	3.96		
Finding an element that I can connect with/resembles with fire	Architect	278	2.60	8.129	0.087
	Landscape A	28	2.50		
	Interior A	27	2.89		
	Psychiatrist	22	2.45		
	Psychologist	28	2.11		
Pyramid-shaped plants	Architect	278	2.57	32.245	0.000
	Landscape A	28	3.64		
	Interior A	27	3.04		
	Psychiatrist	22	2.77		
	Psychologist	28	2.46		
Column-shaped plants	Architect	278	2.82	17.34	0.002
	Landscape A	28	3.57		
	Interior A	27	3.33		
	Psychiatrist	22	2.82		
	Psychologist	28	2.75		
Round-shaped plants	Architect	278	3.00	13.992	0.007
	Landscape A	28	3.68		
	Interior A	27	3.52		
	Psychiatrist	22	3.18		
	Psychologist	28	3.07		
Scattered -shaped plants	Architect	278	3.05	11.85	0.019
	Landscape A	28	3.54		
	Interior A	27	3.67		
	Psychiatrist	22	3.23		
	Psychologist	28	2.86		
Rough textured plants	Architect	278	2.63	13.311	0.01
	Landscape A	28	3.29		
	Interior A	27	2.96		
	Psychiatrist	22	3.05		
	Psychologist	28	2.68		
Medium textured plants	Architect	278	2.89	6.659	0.155
	Landscape A	28	3.43		
	Interior A	27	3.04		
	Psychiatrist	22	3.00		
	Psychologist	28	2.89		
Fine textured plants	Architect	278	3.04	5.397	0.249
	Landscape A	28	3.54		
	Interior A	27	3.04		
	Psychiatrist	22	3.09		
	Psychologist	28	3.00		

Table 7.6 (continued)

Large sized plants	Architect	278	3.24	7.675	0.104
	Landscape A	28	3.36		
	Interior A	27	3.81		
	Psychiatrist	22	3.41		
	Psychologist	28	3.50		
Medium sized plants	Architect	278	3.29	5.47	0.242
	Landscape A	28	3.57		
	Interior A	27	3.67		
	Psychiatrist	22	3.18		
	Psychologist	28	3.50		
Small sized plants	Architect	278	3.30	10.521	0.033
	Landscape A	28	3.93		
	Interior A	27	3.59		
	Psychiatrist	22	3.18		
	Psychologist	28	3.50		
Green-leaved (monochrome) plants	Architect	278	3.76	8.774	0.067
	Landscape A	28	4.04		
	Interior A	27	3.85		
	Psychiatrist	22	4.27		
	Psychologist	28	4.14		
Multi-colored leafy plants	Architect	278	3.47	12.793	0.012
	Landscape A	28	4.11		
	Interior A	27	3.41		
	Psychiatrist	22	4.00		
	Psychologist	28	3.39		
Flowering plants	Architect	278	3.48	18.805	0.001
	Landscape A	28	4.07		
	Interior A	27	3.04		
	Psychiatrist	22	4.27		
	Psychologist	28	3.54		
Pet presence	Architect	278	2.98	3.77	0.438
	Landscape A	28	3.50		
	Interior A	27	2.85		
	Psychiatrist	22	2.86		
	Psychologist	28	2.89		
Presence of a design element to evoke water	Architect	278	3.56	12.535	0.014
	Landscape A	28	4.32		
	Interior A	27	3.26		
	Psychiatrist	22	3.77		
	Psychologist	28	3.71		
Using natural materials (wood, marble, etc.) that change over time	Architect	278	4.28	4.908	0.297
	Landscape A	28	4.29		
	Interior A	27	4.41		
	Psychiatrist	22	4.09		
	Psychologist	28	3.96		
The use of color tones such as soil, green, blue, which reminds of nature	Architect	278	4.00	6.559	0.161
	Landscape A	28	4.43		
	Interior A	27	4.11		
	Psychiatrist	22	4.18		
	Psychologist	28	4.14		
Using materials such as mirrors that reflect light	Architect	278	3.47	4.878	0.3
	Landscape A	28	3.86		
	Interior A	27	3.78		
	Psychiatrist	22	3.23		
	Psychologist	28	3.25		
Getting sunlight	Architect	278	4.90	2.289	0.683
	Landscape A	28	4.86		
	Interior A	27	4.89		
	Psychiatrist	22	4.68		
	Psychologist	28	4.93		
Using spiral forms	Architect	278	2.68	13.352	0.01
	Landscape A	28	3.32		
	Interior A	27	3.00		
	Psychiatrist	22	3.23		
	Psychologist	28	3.00		

Table 7.6 (continued)

Using oval and round forms	Architect	278	2.97	10.857	0.028
	Landscape A	28	3.64		
	Interior A	27	3.30		
	Psychiatrist	22	3.27		
	Psychologist	28	3.21		
Using organic forms	Architect	278	3.31	16.439	0.002
	Landscape A	28	4.18		
	Interior A	27	3.37		
	Psychiatrist	22	3.59		
	Psychologist	28	3.61		
Existence of patterns created by abstraction of animate and inanimate beings/shapes in nature	Architect	278	3.05	15.11	0.004
	Landscape A	28	3.89		
	Interior A	27	3.04		
	Psychiatrist	22	3.14		
	Psychologist	28	3.21		
Using fractal (snowflake, leaf, cone) patterns found in nature	Architect	278	2.95	8.342	0.08
	Landscape A	28	3.50		
	Interior A	27	2.89		
	Psychiatrist	22	3.41		
	Psychologist	28	3.04		
Using contrasts that complement each other (such as using light and dark colors together)	Architect	278	3.78	9.058	0.06
	Landscape A	28	4.07		
	Interior A	27	4.11		
	Psychiatrist	22	3.86		
	Psychologist	28	3.54		
Natural landscape painting presence	Architect	278	2.86	12.601	0.013
	Landscape A	28	3.50		
	Interior A	27	3.04		
	Psychiatrist	22	3.55		
	Psychologist	28	3.25		
Presence of pictures of living things in nature	Architect	278	2.65	11.933	0.018
	Landscape A	28	3.25		
	Interior A	27	2.63		
	Psychiatrist	22	3.27		
	Psychologist	28	2.89		
Presence of objects depicting living things in nature (bird, tree, seashell)	Architect	278	3.04	7.772	0.1
	Landscape A	28	3.54		
	Interior A	27	3.19		
	Psychiatrist	22	3.36		
	Psychologist	28	3.29		

* Statistically significant at $p < 0.05$

In the Table 7.6, "pyramid-shaped plants" are considered the most important by landscape architects, with an average rating of 3.64, and the least important by psychologists, with an average of 2.46. "Column-shaped plants" are rated as most important by landscape architects (3.57) and least important by both psychiatrists and architects, each with an average rating of 2.82. The presence of "round-shaped plants" in biophilic office designs is deemed most important by landscape architects, with an average rating of 3.68, and least important by architects, who rate them 3.00 on average. The inclusion of "scattered-shaped plants" in office designs is found to be most important by interior architects, with an average of 3.67, whereas architects rate their importance the lowest, with an average of 3.05.

When evaluating "rough-textured plants," landscape architects assign the highest importance (3.29), while psychologists rate them the least important, with an average

of 2.68. The significance of "small-sized plants" is considered highest by landscape architects (3.93) and lowest by psychiatrists (3.18). In terms of the presence of "multi-colored leafy plants," landscape architects once again give the highest importance, with an average of 4.11, while psychologists rate them the least important, with an average of 3.39. "Flowering plants" are considered most important by psychiatrists, who assign an average rating of 4.27, while interior architects consider them the least important, with an average of 3.04.

The presence of "a design element that evokes water" is rated as most important by landscape architects (4.32), while interior architects find it the least important (3.26). The importance of "spiral forms" is rated highest by landscape architects (3.32) and lowest by architects (2.68). Similarly, "oval and round forms" are considered most important by landscape architects (3.64), with architects rating them the least important (2.97). The use of "organic forms" is considered most important by landscape architects, with an average rating of 4.18, while architects find them the least important (3.31).

The presence of "patterns abstracted from animate and inanimate forms found in nature" is rated highest by landscape architects (3.89) and least important by interior architects (3.04). "Natural landscape paintings" are deemed most important by psychiatrists (3.55) and least important by architects (2.86). The inclusion of "pictures of living things in nature" is rated most important by psychiatrists (3.27) and least important by interior architects (2.63).

Table 7.7 compares the participants' assessment of the importance of biophilic elements in office design according to whether they have postgraduate education or not

Table 7.7 Date based on the evaluation of biophilic design elements in office designs according to the degree of importance according to whether participants have received postgraduate education

		N	Mean	z	Mann-Whitney U	Sig
Having a nature view	Yes	216	4.19	-2.604	15498.000	0.009
	No	168	3.97			
Finding an element that I can connect with/resembles with fire	Yes	216	2.47	-2.247	15696.000	0.025
	No	168	2.70			
Pyramid-shaped plants	Yes	216	2.60	-1.682	16300.500	0.093
	No	168	2.79			

Column-shaped plants	Yes	216	2.87	-0.861	17150.000	0.389
	No	168	2.96			
Round-shaped plants	Yes	216	3.10	-0.036	17998.500	0.971
	No	168	3.11			

Table 7.7 (continued)

Scattered -shaped plants	Yes	216	3.11	-0.242	17785.000	0.809
	No	168	3.15			
Rough textured plants	Yes	216	2.69	-0.842	17165.000	0.4
	No	168	2.79			
Medium textured plants	Yes	216	2.90	-0.936	17080.000	0.349
	No	168	3.01			
Fine textured plants	Yes	216	3.02	-0.881	17132.500	0.378
	No	168	3.14			
Large sized plants	Yes	216	3.33	-0.054	17980.500	0.957
	No	168	3.31			
Medium sized plants	Yes	216	3.32	-0.473	17561.000	0.636
	No	168	3.38			
Small sized plants	Yes	216	3.34	-0.341	17687.500	0.733
	No	168	3.41			
Green-leaved (monochrome) plants	Yes	216	3.97	-2.898	15082.500	0.004
	No	168	3.68			
Multi-colored leafy plants	Yes	216	3.57	-0.986	17023.000	0.324
	No	168	3.50			
Flowering plants	Yes	216	3.62	-1.255	16731.500	0.21
	No	168	3.44			
Pet presence	Yes	216	2.87	-2.049	15887.000	0.04
	No	168	3.16			
Presence of a design element to evoke water	Yes	216	3.63	-0.202	17828.000	0.84
	No	168	3.60			
Using natural materials (wood, marble, etc.) that change over time	Yes	216	4.26	-0.342	17698.500	0.732
	No	168	4.25			
The use of color tones such as soil, green, blue, which reminds of nature	Yes	216	4.12	-0.913	17122.500	0.361
	No	168	3.98			
Using materials such as mirrors that reflect light	Yes	216	3.44	-0.885	17119.500	0.376
	No	168	3.56			
Getting sunlight	Yes	216	4.93	-2.951	16473.000	0.003
	No	168	4.83			
Using spiral forms	Yes	216	2.86	-0.926	17081.000	0.355
	No	168	2.74			
Using oval and round forms	Yes	216	3.13	-1.094	16902.500	0.274
	No	168	3.01			
Using organic forms	Yes	216	3.38	-0.851	17153.000	0.395
	No	168	3.46			
Existence of patterns created by abstraction of animate and inanimate beings/shapes in nature	Yes	216	3.11	-0.541	17475.000	0.589
	No	168	3.15			
Using fractal (snowflake, leaf, cone) patterns found in nature	Yes	216	3.01	-0.154	17876.500	0.878
	No	168	3.02			
Using contrasts that complement each other (such as using light and dark colors together)	Yes	216	3.71	-1.534	16480.500	0.125
	No	168	3.95			
Natural landscape painting presence	Yes	216	3.00	-0.359	17661.000	0.72
	No	168	2.96			
Presence of pictures of living things in nature	Yes	216	2.72	-0.553	17459.500	0.58
	No	168	2.78			
Presence of objects depicting living things in nature (bird, tree, seashell)	Yes	216	3.12	-0.192	17837.000	0.848
	No	168	3.13			

* Statistically significant at $p < 0.05$

The presence of a nature view in offices is considered most important by participants with postgraduate education in their field, with an average of 4.19, while those without postgraduate education find it less important, with an average of 3.97. Participants without postgraduate education find the presence of “an element that I can connect

with/resembles fire”more important, with an average of 2.70, whereas participants with postgraduate education rate it lower, with an average of 2.47. The presence of green-leaved (monochrome) plants is considered important by participants with postgraduate education, with an average of 3.97, while participants without postgraduate education find it important with a slightly lower average of 3.68. The presence of pets in office designs is considered most important by participants without postgraduate education, with an average of 3.16, whereas participants with postgraduate education rate it lower, with an average of 2.87. When evaluating access to sunlight, it is considered most important by participants with postgraduate education, with an average of 4.93, and least important by those without postgraduate education, with an average of 4.83 (Table 7.7).

Table 7.8 compares the respondents' assessment of the importance of biophilic elements in office design according to their master's or doctoral degree.

Table 7.8 Data based on the evaluation of biophilic design elements in office designs according to the degree of importance according to postgraduate education level in addition to participants

		N	Mean	z	Mann-Whitney U	Sig
Having a nature view	Master d.	120	4.06	-0.572	5696.500	0.568
	PhD.	99	4.18			
Finding an element that I can connect with/resembles with fire	Master d.	120	2.52	-0.388	5764.500	0.698
	PhD.	99	2.46			
Pyramid-shaped plants	Master d.	120	2.69	-0.069	5909.000	0.945
	PhD.	99	2.67			
Column-shaped plants	Master d.	120	2.91	-0.258	5825.000	0.797
	PhD.	99	2.87			
Round-shaped plants	Master d.	120	3.13	-0.583	5679.000	0.56
	PhD.	99	3.00			
Scattered -shaped plants	Master d.	120	3.04	-0.153	5871.000	0.879
	PhD.	99	3.06			
Rough textured plants	Master d.	120	2.71	-0.812	5575.000	0.417
	PhD.	99	2.80			
Medium textured plants	Master d.	120	2.96	-0.213	5845.500	0.832
	PhD.	99	2.96			
Fine textured plants	Master d.	120	2.95	-1.575	5237.000	0.115
	PhD.	99	3.13			
Large sized plants	Master d.	120	3.34	-0.356	5781.500	0.722
	PhD.	99	3.36			
Medium sized plants	Master d.	120	3.31	-0.773	5603.500	0.439
	PhD.	99	3.39			
Small sized plants	Master d.	120	3.38	-0.711	5624.500	0.477
	PhD.	99	3.27			
Green-leaved (monochrome) plants	Master d.	120	3.80	-0.719	5622.500	0.472
	PhD.	99	3.92			
Multi-colored leafy plants	Master d.	120	3.55	-0.837	5566.500	0.403
	PhD.	99	3.67			
Flowering plants	Master d.	120	3.61	-0.438	5743.000	0.662
	PhD.	99	3.69			
Pet presence	Master d.	120	3.24	-2.517	4794.500	0.012
	PhD.	99	2.76			

Table 7.8 (continued)

Presence of a design element to evoke water	Master d.	120	3.73	-1.347	5339.500	0.178
	PhD.	99	3.47			
Using natural materials (wood, marble, etc.) that change over time	Master d.	120	4.30	-0.814	5590.500	0.416
	PhD.	99	4.19			
The use of color tones such as soil. green, blue, which reminds of nature	Master d.	120	4.02	-0.068	5910.500	0.946
	PhD.	99	4.08			
Using materials such as mirrors that reflect light	Master d.	120	3.43	-0.062	5912.000	0.95
	PhD.	99	3.39			
Getting sunlight	Master d.	120	4.91	-0.418	5852.000	0.676
	PhD.	99	4.87			
Using spiral forms	Master d.	120	2.80	-0.288	5810.500	0.773
	PhD.	99	2.85			
Using oval and round forms	Master d.	120	3.18	-1.165	5414.500	0.244
	PhD.	99	2.98			
Using organic forms	Master d.	120	3.50	-0.146	5874.500	0.884
	PhD.	99	3.42			
Existence of patterns created by abstraction of animate and inanimate beings/shapes in nature	Master d.	120	3.10	-0.13	5881.500	0.897
	PhD.	99	3.12			
Using fractal (snowflake, leaf, cone) patterns found in nature	Master d.	120	3.09	-0.14	5877.000	0.889
	PhD.	99	3.07			
Using contrasts that complement each other (such as using light and dark colors together)	Master d.	120	3.83	-0.498	5721.500	0.619
	PhD.	99	3.83			
Natural landscape painting presence	Master d.	120	2.98	-0.616	5661.000	0.538
	PhD.	99	3.06			
Presence of pictures of living things in nature	Master d.	120	2.73	-0.323	5793.500	0.747
	PhD.	99	2.78			
Presence of objects depicting living things in nature (bird, tree, seashell)	Master d.	120	3.08	-1.337	5337.000	0.181
	PhD.	99	3.26			
* Statistically significant at p < 0.05						

The presence of pets in office environments is considered most important by participants with a master's degree, with an average score of 3.24, while participants with a doctoral degree assign it the least importance, with an average score of 2.76 (Table 7.8).

The table below assesses the importance of biophilic elements in office design according to respondents' level of knowledge about biophilic design (7.9).

Table 7.9 Data based on the evaluation of biophilic design elements in office designs according to the level of knowledge about biophilic design

		N	Mean	Kruskal- Wallis H Test	Sig
Having a nature view	Yes	86	4.17	2.285	0.319
	Partially	122	4.11		
	No	175	4.04		
Finding an element that I can connect with/resembles with fire	Yes	86	2.85	8.707	0.013
	Partially	122	2.59		
	No	175	2.42		
Pyramid-shaped plants	Yes	86	3.16	24.415	0.000
	Partially	122	2.68		
	No	175	2.45		
Column-shaped plants	Yes	86	3.34	21.435	0.000
	Partially	122	2.98		
	No	175	2.65		
Round-shaped plants	Yes	86	3.51	21.992	0.000
	Partially	122	3.20		
	No	175	2.83		
Scattered -shaped plants	Yes	86	3.33	11.191	0.004
	Partially	122	3.29		
	No	175	2.91		
Rough textured plants	Yes	86	3.13	12.717	0.002
	Partially	122	2.70		
	No	175	2.55		
Medium textured plants	Yes	86	3.27	11.998	0.002
	Partially	122	2.98		
	No	175	2.77		
Fine textured plants	Yes	86	3.31	11.233	0.004
	Partially	122	3.18		
	No	175	2.89		
Large sized plants	Yes	86	3.62	6.907	0.032
	Partially	122	3.29		
	No	175	3.19		
Medium sized plants	Yes	86	3.56	9.222	0.01
	Partially	122	3.43		
	No	175	3.19		
Small sized plants	Yes	86	3.59	5.500	0.064
	Partially	122	3.39		
	No	175	3.26		
Green-leaved (monochrome) plants	Yes	86	4.07	7.384	0.025
	Partially	122	3.90		
	No	175	3.69		
Multi-colored leafy plants	Yes	86	3.81	7.301	0.026
	Partially	122	3.45		
	No	175	3.46		
Flowering plants	Yes	86	3.73	3.128	0.209
	Partially	122	3.45		
	No	175	3.51		
Pet presence	Yes	86	3.27	5.431	0.066
	Partially	122	3.02		
	No	175	2.84		
Presence of a design element to evoke water	Yes	86	4.07	17.803	0.000
	Partially	122	3.53		
	No	175	3.46		
Using natural materials (wood, marble, etc.) that change over time	Yes	86	4.55	20.367	0.000
	Partially	122	4.30		
	No	175	4.08		
The use of color tones such as soil, green, blue, which reminds of nature	Yes	86	4.43	18.622	0.000
	Partially	122	3.95		
	No	175	3.95		
Finding an element that I can connect with/resembles with fire	Yes	86	3.88	11.172	0.004
	Partially	122	3.47		
	No	175	3.31		
Getting sunlight	Yes	86	4.85	0.326	0.85
	Partially	122	4.89		
	No	175	4.90		
Using spiral forms	Yes	86	3.35	25.116	0.000
	Partially	122	2.68		
	No	175	2.62		

Table 7.9 (continued)

Using oval and round forms	Yes	86	3.52	17.752	0.000
	Partially	122	3.03		
	No	175	2.89		
Using organic forms	Yes	86	3.83	15.679	0.000
	Partially	122	3.47		
	No	175	3.17		
Existence of patterns created by abstraction of animate and inanimate beings/shapes in nature	Yes	86	3.43	8.490	0.014
	Partially	122	3.05		
	No	175	3.03		
Using fractal (snowflake, leaf, cone) patterns found in nature	Yes	86	3.43	14.937	0.001
	Partially	122	2.88		
	No	175	2.91		
Using contrasts that complement each other (such as using light and dark colors together)	Yes	86	3.94	2.745	0.254
	Partially	122	3.67		
	No	175	3.85		
Natural landscape painting presence	Yes	86	3.30	9.140	0.01
	Partially	122	2.81		
	No	175	2.95		
Presence of pictures of living things in nature	Yes	86	3.01	6.033	0.049
	Partially	122	2.61		
	No	175	2.71		
Presence of objects depicting living things in nature (bird, tree, seashell)	Yes	86	3.43	8.736	0.013
	Partially	122	3.11		
	No	175	2.98		

* Statistically significant at $p < 0.05$

When the statements are statistically analyzed based on whether the participants have knowledge about biophilic design (Table 7.9), it is observed that those who answered "Yes" find the presence of "an element that I can connect with/resembles fire" most important, with an average score of 2.85, while those who answered "No" find it the least important, with an average score of 2.42. Participants who answered "Partially" rated this element with an average score of 2.59. Significant statistical differences are found in all statements related to plant forms and textures. For the statement regarding pyramid-shaped plants, participants who answered "Yes" rated it the highest, with an average score of 3.16, while those who answered "No" rated it the lowest, with an average of 2.45. Those who answered "Partially" rated it 2.68. In office designs, the presence of column-shaped plants was rated most important by participants who answered "Yes" (3.34), followed by those who answered "Partially" (2.98), while participants who answered "No" rated it the least important (2.65).

Similarly, for round-shaped plants, participants who answered "Yes" rated it the highest (3.51), followed by those who answered "Partially" (3.20), while those who answered "No" rated it the lowest (2.83). For scattered-shaped plants, participants who answered "Yes" found them most important (3.33), followed closely by those who answered "Partially" (3.29), while those who answered "No" rated them the lowest (2.91). In the case of rough-textured plants, participants who answered "Yes" rated them the highest (3.13), while those who answered "No" rated them the lowest (2.55).

Participants who answered "Partially" rated these plants with an average of 2.70. The presence of medium-textured plants was rated most important by participants who answered "Yes" (3.27), followed by those who answered "Partially" (2.98), while those who answered "No" rated it the least important (2.77). Regarding fine-textured plants, participants who answered "Yes" rated them the highest (3.31), while those who answered "No" rated them the lowest (2.89), with "Partially" responses receiving an average score of 3.18.

For the presence of large-sized plants, those who answered "Yes" found them the most important (3.62), followed by those who answered "Partially" (3.29), while those who answered "No" rated them the least important (3.19). Similarly, the presence of medium-sized plants was rated most important by participants who answered "Yes" (3.56), followed by those who answered "Partially" (3.43), and least important by those who answered "No" (3.19). The presence of green-leaved (monochrome) plants in office designs was rated the highest by participants who answered "Yes" (4.07), followed by "Partially" responses (3.90), while those who answered "No" rated them the lowest (3.69).

Regarding multi-colored leafy plants, participants who answered "Yes" rated them the highest (3.81), while those who answered "Partially" rated them the lowest (3.45), with "No" responses receiving a score of 3.46. The presence of a design element that evokes water was found to be most important by participants who answered "Yes" (4.07), followed by "Partially" responses (3.53), and least important by those who answered "No" (3.46). The use of natural materials that change over time (e.g., wood, marble, etc.) was rated the highest by participants who answered "Yes" (4.55), followed by those who answered "Partially" (4.30), while those who answered "No" rated it the lowest (4.08). The use of colors reminiscent of nature, such as soil, green, and blue, was rated most important by participants who answered "Yes" (4.43), while those who answered "Partially" and "No" rated it the least important, with an average score of 3.95.

The use of materials that reflect light (e.g., mirrors) was rated the highest by participants who answered "Yes" (3.88), followed by those who answered "Partially" (3.56), and the lowest by those who answered "No" (3.31). Regarding the use of forms in office designs, participants who answered "Yes" found spiral forms (3.35), oval and

round forms (3.52), and organic forms (3.83) the most important, while participants who answered "No" rated these forms the least important, with scores of 2.62, 2.89, and 3.17, respectively. Participants who answered "Partially" rated spiral forms with an average of 2.68, oval and round forms with an average of 3.03, and organic forms with an average of 3.47.

In the statement concerning the presence of patterns abstracted from animate and inanimate beings/shapes in nature, participants who answered "Yes" rated it the highest (3.43), while those who answered "No" rated it the lowest (3.03). "Partially" responses received an average score of 3.05. For the use of fractal patterns found in nature (e.g., snowflakes, leaves, cones), participants who answered "Yes" rated it the highest (3.43), followed by those who answered "No" (2.91), while those who answered "Partially" rated it the lowest (2.88).

The presence of natural landscape paintings was rated the highest by participants who answered "Yes" (3.30), followed by those who answered "No" (2.95), and the lowest by those who answered "Partially" (2.81). Finally, the presence of pictures of living things in nature was rated the highest by participants who answered "Yes" (3.01), followed by those who answered "No" (2.71), and the lowest by those who answered "Partially" (2.61). The presence of objects depicting living things (e.g., birds, trees, seashells) was rated the highest by participants who answered "Yes" (3.43), followed by "Partially" responses (3.11), and the lowest by those who answered "No" (2.98).

7.1.2 Visualization of office designs regarding expert survey findings

According to the frequency analysis results of the expert surveys conducted within the scope of this study, biophilic design elements with an average score of 3 and above were identified. These elements, selected by experts, are listed below from highest to lowest based on their frequency in responses (Table 7.2):

- Getting sunlight,
- Using natural materials (wood, marble, etc.) that change over time,
- Having a nature view,

- The use of color tones such as soil, green, blue, which reminds of nature,
- Green-leaved (monochrome) plants,
- Using contrasts that complement each other (such as using light and dark colors together),
- Presence of a design element to evoke water,
- Multi-colored leafy plants,
- Flowering plants,
- Using materials such as mirrors that reflect light,
- Using organic forms,
- Medium sized plants, Small sized plants,
- Existence of patterns created by abstraction of animate and inanimate beings/shapes in nature,
- Presence of objects depicting living things in nature (bird, tree, seashell),
- Scattered -shaped plants,
- Round-shaped plants,
- Fine textured plants,
- Using oval and round forms,
- Using fractal (snowflake, leaf, cone) patterns found in nature.

The biophilic office reflects the key features identified by experts, integrating natural light, organic materials, nature-inspired colors, and vegetation. In contrast, the non-biophilic office lacks these elements, serving as a counterpart for comparative analysis. The texture, size, and other physical characteristics of plants directly influence the design. In the survey, the presence of plants was examined based on these attributes. However, considering that each biophilic element should have an equally

dominant impact on the design, the presence of plants was visualized as a general element. The biophilic office elements and the way they are integrated into the design are given in Figure 7.1.

Biophilic Design Element	Integration into Design
Getting Sunlight	Large windows maximize natural light, enhancing well-being and productivity.
Using Natural Materials (Wood, Marble, etc.)	Natural materials like wood and marble develop a unique patina over time, adding authenticity.
Having a Nature View	Office layout is designed to provide views of nature, reducing stress and increasing creativity.
Nature-Inspired Colors (Soil, Green, Blue)	Soil, green, and blue tones are used in walls and decor to evoke a calming, nature-inspired atmosphere.
Using Contrasting Colors (Light & Dark)	Light and dark color contrasts mimic the depth found in nature, adding visual interest.
Presence of a Design Element to Evoke Water	Water features like small indoor fountains or textures resembling water enhance tranquility.
Indoor Plants	A variety of indoor plants are incorporated to add texture, depth, and improve air quality.
Using Materials Such as Mirrors that Reflect Light	Strategic placement of mirrors enhances the perception of space and maximizes natural light reflection.
Using Organic Forms	Furniture and decor incorporate organic, flowing shapes to harmonize with nature.
Medium & Small-Sized Plants	A mix of medium and small plants provides a balanced, layered aesthetic in the office.
Abstract Patterns from Nature	Abstracted patterns derived from nature (e.g., leaves, waves) are used in design elements.
Presence of Objects Depicting Living Things (Bird, Tree, Seashell)	Decorative elements featuring birds, trees, or seashell motifs strengthen the biophilic connection.
Using Oval and Round Forms	Round and oval forms in furniture and layout soften the design and create a welcoming ambiance.
Using Fractal Patterns (Snowflake, Leaf, Cone)	Fractal patterns found in nature (like snowflakes and leaves) are reflected in wall art and decor.

Figure 7.1 Integration of biophilic design elements to office

Both office designs share the same layout and have been structured in alignment with contemporary office environments. The distinction between the biophilic and non-biophilic offices is solely reflected through the materials and finishes used. These designs are presented in Figure 7.2.



- **Windows:** Large windows are used to highlight natural light and view.
- **Indoor Water Feature:** A small indoor water feature is included in the design to establish a connection with water.
- **Abstract Natural Paintings:** Artwork depicting natural scenes or abstract representations of nature is used to bring an organic and calming element to the office.
- **Animal Figures:** Sculptures or figures of animals are incorporated into the design, adding a touch of nature and possibly whimsy to the office space.
- **Furniture:** Furniture is designed using organic shapes and oval forms
- **Mirror:** Mirror is strategically placed to not only enhance the perception of space but also to reflect natural light.
- **Wall Colors:** Contrast is created in the space by using light and dark natural tones on the walls.
- **Indoor Plants:** Different sizes, shapes, textures and, colors of plants are used in the office.



- **Light:** limiting the entry of natural light and view.
- **Materials:** Unnatural materials such as artificial leather, ceramic are preferred instead of using natural materials which have patina

Figure 7.2 Biophilic and non biophilic office designs

Based on expert survey findings, a biophilic office environment was designed to integrate key natural elements that enhance well-being, productivity, and spatial comfort. This office features ample natural light, the use of organic materials such as wood and marble that develop a patina over time, and a direct visual connection with nature. Additionally, earthy tones—including shades of green, blue, and soil-inspired

hues—are incorporated to evoke a natural ambiance. The presence of green-leaved plants, multi-colored foliage, and flowering plants contributes to a more dynamic and restorative workspace. The design also emphasizes contrast through complementary light and dark tones, the use of reflective materials such as mirrors to enhance natural light distribution, and water-inspired elements that reinforce a connection to nature. Furthermore, organic and fractal patterns derived from natural forms like snowflakes, leaves, and cones are embedded into the design, along with sculptural objects depicting elements of the natural world, such as birds, trees, and seashells. These features collectively establish an office space that prioritizes psychological comfort, cognitive engagement, and biophilic interaction, as illustrated in Figure 7.2.

In contrast, the non-biophilic office was developed following an industrial design approach, devoid of natural elements but still emphasizing a structured and contemporary aesthetic. This office does not incorporate biophilic features such as vegetation, organic forms, or natural material textures, instead relying on synthetic materials such as artificial leather and ceramics. Additionally, natural light is restricted, resulting in a more enclosed atmosphere. Despite the absence of biophilic components, design integrity was maintained, ensuring the space aligns with modern office standards. The comparison between these two distinct approaches, as presented in Figure 7.1, highlights the role of material selection and environmental elements in shaping workplace experiences and overall spatial perception.

7.2 Findings regarding experiment data

In this section, the findings related to physiological parameters, attentional performance and momentary emotional states are presented in detail. Physiological parameters measured within the scope of the study consist of basic vital signs such as blood pressure, pulse rate, body temperature and partial oxygen pressure. These data were collected to objectively assess the physiological states of the participants.

Various psychometric scales and performance tests were used to measure attention levels and momentary emotional states. In particular, the State Anxiety Scale was applied to determine the level of state anxiety and the momentary anxiety levels of the individuals were measured. In the evaluation of attention performance, the D2 Attention Test, which measures the speed and accuracy of attention processes, was

used. Through this test, data on attention performance were obtained and attention levels were analysed comprehensively.

In addition, EEG (Electroencephalography) data were examined to evaluate neurophysiological parameters.

Table 7.10 presents the demographic information of the participants who participated in the experimental phase of the thesis study.

Table 7.10 Demographic data

Variables		Frequency	Percent(%)
Gender	Female	15	50.0
	Male	15	50.0
Age	24-34	19	63.30
	35-	11	36.70
Profession	Academician	17	56.70
	Student	6	20.00
	Other*	7	23.30
Have you had any previous experience with VR?	No	19	63.30
	Yes	11	36.70
Have you got any information about biophilic design?	I have got any knowledge	22	73.30
	I have got little knowledge	5	16.70
	I have got knowledge	3	10.00

*Other; Electrical engineer, Electrical technician, Occupational health and Safety specialist, Civil servant, Architect, Landscape architect

A total of 30 people, 15 male and 15 female, participated in the study. 63.3% of the participants were between the ages of 24 and 34, and 36.7% were 35 years or older. Regarding the professions of the participants, 56.7% were academicians, 20% were students, and 23.3% were in other professions. While 63.3% of the participants had never experienced VR before, 36.7% had. When the participants were asked whether they had any knowledge about biophilic design, 73.3% stated that they had no knowledge, 16.7% stated that they had little knowledge, and 10% stated that they had knowledge (Table 7.10)

7.2.1 Findings regarding Physiological parameters

The physiological parameters obtained within the scope of the study consist of basic vital signs such as blood pressure, pulse rate, body temperature and partial oxygen pressure. These parameters were collected to examine the physiological responses of the participants in both office environments and analysed in detail according to their demographic characteristics. The analyses aim to reveal the differences in the physiological responses of the participants based on variables such as age, gender and

occupational status. In this context, a comparative evaluation of the findings obtained in both environments was made and presented.

Table 7.1 compares the mean values, standard deviations (SD), minimum and maximum values of variables (blood pressure, pulse, body temperature, salivary cortisol level and SpO₂) in biophilic and non-biophilic environments and assesses statistical significance.

Table 7.11 Data based Physiological parameters

Variables		Biophilic			Non-Biophilic			Test statistics; Sig. (p)
		Mean	SD.	Min-max	Mean	SD.	Min-max	
Blood pressure (mmHg)	Cystolic	114.13	10.81	97.00-135.00	116.53	12.25	93.00-150.00	-1.176* 0.249
	Dialstolic	71.47	9.25	58.00-95.00	72.40	10.11	52.00-.5.00	-0.525* 0.604
Pulse (beat/min)		75.93	7.50	64.00-90.00	78.63	9.19	31.10-99.00	-2.488* 0.019
Body temperature (°C)		36.42	0.53	35.00-37.70	36.42	0.41	35.10-36.90	-0.284** 0.776
Saliva Cortisol Level (ng/mL)		0.19	0.15	0,06-0,07	0.19	0.17	0.05-0.900	-0.076** 0.940
SpO ₂ (%)		98.80	0.55	97.00-99.00	98.70	0.83	95.00-99.00	-0.879** 0.380

*Paired sample t testi (t)
**Wilcoxon Signed Ranks Test (Z)
Statistically significant at p < 0.05

The pulse levels of the participants were found to be 75.93±7.50 beats/minute in the biophilic environment and 78.63±9.19 beats/minute in the non-biophilic environment, and it was determined that the pulse levels were significantly higher in the non-biophilic environment (Table 7.11).

Tables 7.12 and 7.13 compare participants' physical responses by gender in biophilic and non-biophilic environments and assess the statistical differences between them using both between-group and within-group measures and are presented below.

Table 7.12 Data Based on Physical Responses of Participants According to Gender in Biophilic and Non-Biophilic Environments (Between-Group Comparison)

Variables		Biophilic			Non-Biophilic		
		Female	Male	Test statistics; Sig. (p)	Female	Male	Test statistics; Sig. (p)
		Mean±SD	Mean±SD		Mean±SD	Mean±SD	
Blood pressure (mmHg)	Cystolic	109.53±8.38	118.73±11.25	0.440* 0.017	110.93±9.11	122.13±12.68	0.198* 0.010
	Dialstolic	69.67±6.87	73.27±11.09	0.054* 0.294	70.13±8.92	74.67±11.01	0.409* 0.226
Pulse (beat/min)		76.80±7.89	75.07±7.25	0.641* 0.536	79.13±8.58	78.13±10.04	0.660* 0.536
Body temperature (°C)		36.52±0.60	36.33±0.46	-1.283** 0.217	36.45±0.47	36.39±0.37	-0.965** 0.345
SpO ₂ (%)		98.80±0.56	98.80±0.56	0.000** 1.000	98.93±0.26	98.47±1.13	-1.503** 0.345
Saliva Cortisol Level (ng/mL)		0.21±0.19	0.17±0.10	-0.270** 0.345	0.21±0.22	0.18±0.09	-0.726** 0.486

* T Test (t)

**Mann Whitney U Test(Z)

Statistically significant at p < 0.05

In the non-biophilic environment, the mean systolic blood pressure of female participants was 110.93±9.11 mmHg, while the mean systolic blood pressure of male participants was 122.13±12.68 mmHg (Table 7.12).

In the non-biophilic environment, the mean systolic blood pressure of female participants was 110.93±9.11 mmHg, while the mean systolic blood pressure of male participants was 122.13±12.68 mmHg (Table 7.12).

Table 7.13 Data Based on Physical Responses of Participants According to Gender in Biophilic and Non-Biophilic Environments (Within-Group Comparison)

		Female			Male		
Variables		Biophilic	Non-Biophilic	Test statistics;	Biophilic	Non-Biophilic	Test statistics;
		Mean±SD	Mean±SD	Sig. (p)	Mean±SD	Mean±SD	Sig. (p)
Blood pressure (mmHg)	Cystolic	109.53±	110.93±	-0.495*	118.73±	122.13±	-1.128*
		8.38	9.11	0.628	11.25	12.68	0.278
	Dialstolic	69.67±	70.13±	-0.195*	73.27±	74.67±	-0.516*
		6.87	8.92	0.848	11.09	11.01	0.614
Pulse (beat/min)		76.80±	79.13±	-1.592*	75.07±	78.13±	-1.863*
		7.89	8.58	0.134	7.25	10.04	0.084
Body temperature (°C)		36.52±	36.45±	-0.589**	36.33±	36.39±	0.315**
		0.60	0.47	0.556	0.46	0.37	0.673
SpO ₂ (%)		98.80±	98.93±	-1.414**	98.80±	98.47±	-1.518**
		0.56	0.26	0.157	0.56	1.13	0.129
Saliva Cortisol Level (ng/mL)		98.80±	98.93±	-1.005**	0.17±	0.18±	-0.852**
		0.19	0.22	0.315	0.10	0.09	0.394**

*Paired sample t test (t)

**Wilcoxon Signed Ranks Test (Z)

Statistically significant at p < 0.05

There was no significant statistical difference between genders and both environments (Table 7.13).

Tables 7.14 and 7.15 compare the physical responses of participants by age group in biophilic and non-biophilic environments and assess statistical differences. The

analyses examine physical responses as a function of age using between-group and within-group measures.

7.14 Data Based on Physical Responses of Participants According to Age in Biophilic and Non-Biophilic Environments (Between-Group Comparison)

Variables		Biophilic			Non-Biophilic		
		24-34	35-	Test statistics; Sig. (p)	24-34	35-	Test statistics; Sig. (p)
Blood pressure (mmHg)	Cystolic	115.47±11.78	111.82±8.94	0.889* 0.382	118.21±12.93	113.64±10.94	0.985* 0.333
	Dialstolic	70.32±8.56	73.45±10.46	-0.892* 0.380	72.32±8.96	72.55±12.32	-0.059* 0.953
Pulse (beat/min)		77.42±6.91	73.36±8.10	1.456* 0.157	79.63±9.45	76.91±8.88	0.777* 0.444
Body temperature (°C)		36.47±0.57	36.34±0.48	-0.917** 0.372	36.42±0.49	36.43±0.26	-0.718** 0.497
SpO ₂ (%)		98.79±0.54	98.82±0.60	-0.437** 0.800	98.84±0.50	98.45±1.21	-1.161** 0.471
Saliva Cortisol Level (ng/ml)		0.22±0.17	0.13±0.05	-1.140** 0.268	0.22±0.20	0.14±0.05	-1.205** 0.232

* T Test (t)

**Mann Whitney U Test(Z)

Statistically significant at $p < 0.05$

The body reactions of the participants did not show a statistically significant difference according to age groups in both environments (Table 7.14).

7.15 Data Based on Physical Responses of Participants According to Age in Biophilic and Non-Biophilic Environments (Within-Group Comparison)

		24-34			35-		
Variables		Biophilic	Non-Biophilic	Test statistics;	Biophilic	Non-Biophilic	Test statistics;
		Mean±SD	Mean±SD	Sig. (p)	Mean±SD	Mean±SD	Sig. (p)
Blood pressure (mmHg)	Cystolic	115.47±	118.21±	-0.972*	111.82±	113.64±	-0.634*
		11.78	12.93	0.344	8.94	10.94	0.541
	Dialstolic	70.32±	72.32±	-0.911*	73.45±	72.55±	0.295*
		8.56	8.96	0.374	10.46	12.32	0.774
Pulse (beat/min)		77.42±	79.63±	-1.748*	73.36±	76.91±	-1.725*
		6.91	9.45	0.098	8.10	8.88	0.115
Body temperature (°C)		36.47±	36.42±	-0.803**	36.34±	36.43±	-0.641**
		0.57	0.49	0.422	0.48	0.26	0.521
SpO ₂ (%)		98.79±	98.84±	-0.378**	98.82±	98.45±	-1.633**
		0.54	0.50	0.705	0.60	1.21	0.102
Saliva Cortisol Level (ng/mL)		0.22±	0.22±	-0.866**	0.13±	0.14±	-1.274**
		0.17	0.20	0.705	0.05	0.05	0.203

*Paired sample t test (t)

**Wilcoxon Signed Ranks Test (Z)

Statistically significant at $p < 0.05$

There was no statistically significant difference between age groups or the office designs (Table 7.15).

Table 7.16 and Table 7.17 compare the physical responses of participants by occupational group in biophilic and non-biophilic environments and assess statistical differences both between-group and within-group

7.16 Data Based on Physical Responses of Participants According to profession in Biophilic and Non-Biophilic Environments (Between-Group Comparison)

Variables		Biophilic				Non-Biophilic			
		Academician	Student	Other	Test statistics; Sig. (p)	Academician	Student	Other	Test statistics; Sig. (p)
		Mean±SD	Mean±SD	Mean±SD		Mean±SD	Mean±SD	Mean±SD	
Blood pressure (mmHg)	Cystolic	111.65±8.67	124.50±12.83	111.29±9.66	4.213* 0.026	114.35±10.97	126.00±14.49	113.71±10.83	2.474* 0.103
	Dialstolic	71.65±7.64	67.33±10.27	74.57±11.90	0.996* 0.382	71.88±8.30	70.67±8.78	75.14±15.29	0.351* 0.707
Pulse (beat/min)		76.18±6.88	77.00±9.84	74.43±7.81	0.199* 0.821	79.12±9.85	79.67±10.60	76.57±7.00	0.225* 0.800
Body temperature (°C)		36.48±0.56	36.45±0.38	36.27±0.62	0.046** 0.831	36.45±0.45	36.57±0.26	36.23±0.41	0.062** 0.803
SpO ₂ (%)		98.65±0.70	99.00±0.00	99.00±0.00	1.620** 0.203	98.71±0.99	99.00±0.00	98.43±0.79	0.738** 0.390
Saliva Cortisol Level (ng/mL)		0.14±0.07	0.24±0.20	0.25±0.21	0.706** 0.401	0.14±0.08	0.28±0.31	0.24±0.13	0.593** 0.441

* One Way Anova (F)

**Kruskal Wallis (H)

Statistically significant at p < 0.05

In the biophilic office, the systolic blood pressure of students (124.50) is higher than the systolic blood pressure of academics (111.65) and participants from other occupational groups (111.29), as seen in table 7.16.

7.17 Data Based on Physical Responses of Participants According to profession in Biophilic and Non-Biophilic Environments (Within-Group Comparison)

Variables		Academician			Student			Other		
		Biophilic	Non-Biophilic	Test statistics; Sig. (p)	Biophilic	Non-Biophilic	Test statistics; Sig. (p)	Biophilic	Non-Biophilic	Test statistics; Sig. (p)
		Mean±SD	Mean±SD		Mean±SD	Mean±SD		Mean±SD	Mean±SD	
Blood pressure (mmHg)	Cystolic	111.65±8.67	114.35±10.97	-0.907* 0.378	124.50±12.83	126.00±14.49	-0.410* 0.699	111.29±9.66	113.71±10.83	-0.559* 0.597
	Dialstolic	71.65±7.64	71.88±8.30	-0.107* 0.916	67.33±10.27	70.67±8.78	-0.942* 0.389	74.57±11.90	75.14±15.29	-0.116* 0.912
Pulse (beat/min)		76.18±6.88	79.12±9.85	-1.742* 0.101	77.00±9.84	79.67±10.60	-1.896* 0.116	74.43±7.81	76.57±7.00	-1.016* 0.349
Body temperature (°C)		36.48±0.56	36.45±0.45	-0.179** 0.858	36.45±0.38	36.57±0.26	-0.736** 0.461	36.27±0.62	36.23±0.41	-0.954** 0.340
SpO ₂ (%)		98.65±0.70	98.71±0.99	-0.378** 0.705	99.00±0.00	99.00±0.00	-0.00** 1.00	99.00±0.00	98.43±0.79	-1.633** 0.102
Saliva Cortisol Level (ng/mL)		0.14±0.07	0.14±0.08	-0.440** 0.660	0.24±0.20	0.28±0.31	-0.526** 0.599	0.25±0.21	0.24±0.13	0.000** 1.000

*Paired sample t test (t)

**Wilcoxon Signed Ranks Test (Z)

Statistically significant at p < 0.05

Biophilic and non-biophilic workplace designs based on the physiological reactions of participants were compared according to profession. The results indicated no statistically significant differences (Table 7.17).

Table 7.18 and Table 7.19.20 compare the physical responses of participants with and without prior virtual reality (VR) experience in biophilic and non-biophilic environments and assess the statistical differences between them using both between-group and within-group analyses

7.18 Data Based on Physical Responses of Participants According to whether they have previous VR experience in Biophilic and Non-Biophilic Environments (Between-Group Comparison)

		Biophilic			Non-Biophilic		
Variables		No	Yes	Test statistics;	No	Yes	Test statistics;
		Mean±SD	Mean±SD	Sig. (p)	Mean±SD	Mean±SD	Sig. (p)
Blood pressure (mmHg)	Cystolic	113.79±	114.73±	-0.225	116.05±	117.36±	-0.278
		11.69	9.61	0.824	14.05	8.88	0.783
	Dialstolic	70.37±	73.36±	-0.851	71.68±	73.64±	-0.503
		7.87	11.42	0.402	7.53	13.85	0.619
Pulse (beat/min)		75.32±	77.00±	-0.586	77.11±	81.27±	-1.206
		7.33	8.01	0.562	9.81	7.71	0.238
Body temperature (°C)		36.42±	36.44±	-0.982**	36.43±	36.42±	-0.087**
		0.55	0.54	0.326	0.42	0.42	0.931
SpO ₂ (%)		98.74±	98.91±	-0.583**	98.74±	98.64±	-1.095**
		0.65	0.30	0.560	0.93	0.67	0.274
Saliva Cortisol Level (ng/mL)		0.14±	0.26±	-1.571**	0.14±	0.28±	-2.346**
		0.08	0.21	0.116	0.07	0.24	0.019

* T Test (t)

**Mann Whitney U Test(Z)

Statistically significant at p < 0.05

According to Table 7.18, the average salivary cortisol level of male participants who had previous VR experience in a non-biophilic environment was 0.28 (ng/ml), while it was 0.14 (ng/ml) for participants who had not experienced VR before.

7.19 Data Based on Physical Responses of Participants According to whether they have previous VR experience in Biophilic and Non-Biophilic Environments (Within-Group Comparison)

		No			Yes		
Variables		Biophilic	Non-Biophilic	Test statistics;	Biophilic	Non-Biophilic	Test statistics;
		Mean±SD	Mean±SD	Sig. (p)	Mean±SD	Mean±SD	Sig. (p)
Blood pressure (mmHg)	Cystolic	113.79±	116.05±	-0.834*	114.73±	117.36±	-0.833*
		11.69	14.05	0.415	9.61	8.88	0.424
	Dialstolic	70.37±	71.68±	-0.668*	73.36±	73.64±	-0.076*
		7.87	7.53	0.512	11.42	13.85	0.941
Pulse (beat/min)		75.32±	77.11±	-1.232*	77.00±	81.27±	-2.778*
		7.33	9.81	0.234	8.01	7.71	0.020
Body temperature (°C)		36.42±	36.43±	-0.396**	36.44±	36.42±	-0.938**
		0.55	0.42	0.692	0.54	0.42	0.348
SpO ₂ (%)		98.74±	98.74±	0.000**	98.91±	98.64±	-1.134**
		0.65	0.93	1.000	0.30	0.67	0.257
Saliva Cortisol Level (ng/mL)		0.14±	0.14±	-0.501**	0.26±	0.28±	-0.445**
		0.08	0.07	0.616	0.21	0.24	0.257

*Paired sample t test (t)

**Wilcoxon Signed Ranks Test (Z)

Statistically significant at p < 0.05

The heart rate of the participants who had previously experienced VR was higher in the non-biophilic office (81.27) than biophilic office (77.00) (Table 7.19).

Table 7.20 and Table 7.21 compare participants' physical responses to biophilic design knowledge in biophilic and non-biophilic environments and assess the statistical differences between these variables through both between-group and within-group analyses.

7.20 Data Based on Physical Responses of Participants According to to knowledge about biophilic design in Biophilic and Non-Biophilic Environments (Between-Group Comparison)

		Biophilic				Non-Biophilic			
Variables		Any knowledge	Little knowledge	Much knowledge	Test statistics;	Any knowledge	Little knowledge	Much knowledge	Test statistics;
		Mean±SD	Mean±SD	Mean±SD	Sig. (p)	Mean±SD	Mean±SD	Mean±SD	Sig. (p)
Blood pressure (mmHg)	Cystolic	114.14±	116.40±	110.33±	0.280*	117.64±	116.20±	109.00±	0.642*
		11.96	7.23	7.37	0.758	12.75	10.89	11.53	0.534
	Dialstolic	70.32±	76.80±	71.00±	1.005*	72.55±	74.80±	67.33±	0.502*
		9.55	5.89	11.27	0.379	8.38	16.39	12.42	0.611
Pulse (beat/min)		76.05±	77.80±	72.00±	0.553*	78.27±	80.80±	77.67±	0.163*
		7.10	7.95	11.27	0.582	9.38	8.04	12.50	0.851
Body temperature (°C)		36.40±	36.38±	36.63±	0.845**	36.45±	36.22±	36.60±	1.770**
		0.59	0.44	0.15	0.655	0.41	0.50	0.10	0.413
SpO ₂ (%)		98.73±	99.00±	99.00±	1.614**	98.68±	98.60±	99.00±	0.673**
		0.63	0.00	0.00	0.446	0.89	0.89	0.00	0.714
Saliva Cortisol Level (ng/mL)		0.19±	0.19±	0.16±	0.586**	0.20±	0.19±	0.14±	1.606**
		0.17	0.09	0.09	0.746	0.19	0.05	0.08	0.448

* One Way Anova (F)

**Kruskal Wallis (H)

Statistically significant at p < 0.05

As seen in Table 7.20 There was no significant statistical correlation between the participants' awareness of biophilic design and their physical responses.

7.21 Data Based on Physical Responses of Participants According to to knowledge about biophilic design in Biophilic and Non-Biophilic Environments (Within-Group Comparison)

		Any knowledge			Little knowledge			Much knowledge		
Variables		Biophilic	Non-Biophilic	Test statistics; Sig. (p)	Biophilic	Non-Biophilic	Test statistics; Sig. (p)	Biophilic	Non-Biophilic	Test statistics; Sig. (p)
		Mean±SD	Mean±SD		Mean±SD	Mean±SD		Mean±SD	Mean±SD	
Blood pressure (mmHg)	Cystolic	114.14±	117.64±	-1.413*	116.40±	116.20±	0.037*	110.33±	109.00±	0.329*
		11.96	12.75	0.172	7.23	10.89	0.972	7.37	11.53	0.774
	Dialstolic	70.32±	72.55±	-1.407*	76.80±	74.80±	0.267*	71.00±	67.33±	0.498*
		9.55	8.38	0.174	5.89	16.39	0.803	11.27	12.42	0.668
Pulse (beat/min)		76.05±	78.27±	-1.887*	77.80±	80.80±	-0.730*	72.00±	77.67±	-4.250*
		7.10	9.38	0.073	7.95	8.04	0.506	11.27	12.50	0.051
Body temperature (°C)		36.40±	36.45±	-0.379**	36.38±	36.22±	-1.289*	36.63±	36.60±	-1.000**
		0.59	0.41	0.704	0.44	0.50	0.197	0.15	0.10	0.317
SpO ₂ (%)		98.73±	98.68±	-0.333**	99.00±	98.60±	-1.000**	99.00±	99.00±	0.000**
		0.63	0.89	0.739	0.00	0.89	0.317	0.00	0.00	1.000
Saliva Cortisol Level (ng/mL)		0.19±	0.20±	-0.016**	0.19±	0.19±	-0.405**	0.16±	0.14±	-1.342**
		0.17	0.19	0.987	0.09	0.05	0.686	0.09	0.08	0.180

*Paired sample t test (t)

**Wilcoxon Signed Ranks Test (Z)

Statistically significant at p < 0.05

According to the data in Table 7.21, the significant difference was observed in pulse levels. Participants who had ‘a lot of knowledge’ about biophilic design had significantly lower pulse levels in the biophilic office (72.00±11.27) compared to the non-biophilic office (77.67±12.50)

7.2.2 Findings regarding psychometric parameters

In this section, the data obtained from the D2 attention test and state anxiety scale are presented and evaluated within the framework of demographic information according to biophilic and non-biophilic office environments.

Table 7.22 compares the D2 attention test results of participants in biophilic and non-biophilic environments and assesses the attentional performance between these two environments.

7.22 Data Based on D2 Attention Test of Participants in Biophilic and Non-Biophilic Environments

Variables	Biophilic			Non-Biophilic			Test statistics; Sig. (p)
	Mean	SD.	Min-max	Mean	SD.	Min-max	
TN	601.03	59.57	445.00-653.00	593.60	74.99	297.00-653.00	-0.529** 0.597
E1	31.13	34.94	0.00-109.00	32.13	33.24	2.00-104.00	-0.076** 0.939
E2	10.97	36.56	0.00-157.00	9.63	31.33	0.00-129.00	-0.177** 0.860
TN-E	593.62	60.13	445.00-652.54	586.60	75.96	291.97-652.98	-0.463** 0.644
CP	222.13	52.42	26.00-294.00	235.73	43.79	166.00-322.00	-0.730** 0.465
FR	5.97	3.76	1.00-13.00	7.20	4.56	1.00-14.00	-1.459** 0.144

**Wilcoxon Signed Ranks Test (Z)

Statistically significant at $p < 0.05$

According to the results of the D2 Attention Test, no significant difference was found between the participants' attention performances in biophilic and non-biophilic environments (7.22).

Table 7.23 and Table 7.24 present participants' performance on the D2 attention test in biophilic and non-biophilic environments and between-group and Within-Group comparisons by gender.

7.23 Data Based on D2 Attention Test of Participants According to gender in Biophilic and Non-Biophilic Environments (Between-Group Comparison)

	Biophilic			Non-Biophilic		
Variables	Female	Male	Test statistics; Sig. (p)	Female	Male	Test statistics; Sig. (p)
	Mean±SD	Mean±SD		Mean±SD	Mean±SD	
TN	617.00 ± 48.28	585.07± 66.87	-1.400** 0.162	598.20± 90.49	589.00± 58.44	-0.916** 0.360
E1	38.40± 39.86	23.87± 28.76	-1.474** 0.140	37.47± 36.81	26.80± 29.55	-0.643** 0.520
E2	10.47± 40.54	11.47± 33.54	-2.215** 0.027	8.87± 33.24	10.40± 30.45	-1.390** 0.170
TN-E	609.29± 46.49	577.95± 69.29	-1.307** 0.191	590.69± 50.58	582.50± 60.94	-0.892** 0.373
CP	215.33± 66.03	228.93± 35.13	-0.311** 0.756	239.27± 49.41	232.20± 38.77	-0.498** 0.619
FR	5.07± 3.63	6.87± 3.80	-1.092** 0.275	6.33± 4.58	8.07± 4.53	-0.986** 0.324
**Mann Whitney U Test(Z) Statistically significant at p < 0.05						

According to Table 7.23, the mean E2 value in the D2 attention test conducted in a biophilic environment was 10.47 for female participants and 11.47 for male participants. This means that, on average, male participants scored slightly higher than female participants on the E2 variable of the D2 attention test when tested in a workspace designed with biophilic elements

7.24 Data Based on D2 Attention Test of Participants According to gender in Biophilic and Non-Biophilic Environments (Within-Group Comparison)

	Female			Male		
Variables	Biophilic	Non-Biophilic	Test statistics; Sig. (p)	Biophilic	Non-Biophilic	Test statistics; Sig. (p)
	Mean±SD	Mean±SD		Mean±SD	Mean±SD	
TN	617.00±	598.20±	-0.341**	585.07±	589.00±	-0.235**
	48.28	90.49	0.733	66.87	58.44	0.814
E1	38.40±	37.47±	-0.942**	23.87±	26.80±	-1.296**
	39.86	36.81	0.346	28.76	29.55	0.195
E2	10.47±	8.87±	-0.368**	11.47±	10.40±	-0.060**
	40.54	33.24	0.713	33.54	30.45	0.195
TN-E	609.29±	590.69±	-0.341**	577.95±	582.50±	-0.227**
	46.49	90.58	0.733	69.29	60.94	0.820
CP	215.33±	239.27±	-3.408**	228.93±	232.20±	-3.408**
	66.03	49.41	<.001	35.13	38.77	<.001
FR	5.07±	6.33±	-0.881**	6.87±	8.07±	-1.342**
	3.63	4.58	0.378	3.80	4.53	0.180

**Wilcoxon Signed Ranks Test (Z)
Statistically significant at p < 0.05

The average CP value of female participants was 239.27 in the non-biophilic office design, while it was 215.33 in the biophilic office design. Similarly, the CP value of male participants was 232.20 in the non-biophilic office design, compared to 228.93

in the biophilic office design. These differences were statistically significant for both female and male participants (Table 7.24).

Table 7.25 and Table 7.26 assess D2 attention test performance by age groups of participants in biophilic and non-biophilic environments and present between-group and within-group comparisons.

7.25 Data Based on D2 Attention Test of Participants According to Age in Biophilic and Non-Biophilic Environments (Between-Group Comparison)

Variables	Biophilic			Non-Biophilic		
	24-34	35-	Test statistics; Sig. (p)	24-34	35-	Test statistics; Sig. (p)
TN	Mean±SD	Mean±SD		Mean±SD	Mean±SD	
	588.32±67.81	623.00±34.28	-0.844** 0.398	607.95±56.90	568.82±97.02	-1.599** 0.110
E1	20.68±25.09	49.18±42.92	-1.961** 0.050	23.74±28.22	46.64±37.49	-1.852** 0.064
	9.05±29.97	14.27±47.34	-1.412** 0.158	8.21±27.21	12.09±38.78	-0.269** 0.788
TN-E	582.57±70.23	612.71±31.17	-0.581** 0.561	602.56±59.42	559.02±95.18	-1.915** 0.055
	220.53±60.77	224.91±36.18	-0.043** 0.966	251.00±41.86	209.36±34.62	-2.325** 0.020
FR	6.11±4.12	5.73±3.23	-0.414** 0.679	6.21±4.63	8.91±4.09	-1.567** 0.117

**Mann Whitney U Test(Z)

Statistically significant at $p < 0.05$

In the biophilic environment, the E1 value of the D2 attention test was 20.68 on average for participants aged 24-34, while it was 49.18 for participants over 35 years of age. The average CP value calculated in a non-biophilic environment is 251 in participants aged 24-34, while it is 209.36 in participants over 35 years old (Table 7.25)

7.26 Data Based on D2 Attention Test of Participants According to Age in Biophilic and Non-Biophilic Environments (Within-Group Comparison)

Variables	24-34			35-		
	Biophilic	Non-Biophilic	Test statistics; Sig. (p)	Biophilic	Non-Biophilic	Test statistics; Sig. (p)
TN	Mean±SD	Mean±SD		Mean±SD	Mean±SD	
	588.32±67.81	607.95±56.90	-1.655** 0.098	623.00±34.28	568.82±97.02	-2.578** 0.010
E1	20.68±25.09	23.74±28.22	-0.544** 0.586	49.18±42.92	46.64±37.49	-0.869** 0.385
	9.05±29.97	8.21±27.21	-0.060** 0.952	14.27±47.34	12.09±38.78	-0.368** 0.713
TN-E	582.57±70.23	602.56±59.42	-1.569** 0.952	612.71±31.17	559.02±95.18	-2.578** 0.010
	220.53±60.77	251.00±41.86	-2.275** 0.023	224.91±36.18	209.36±34.62	-1.511** 0.131
FR	6.11±4.12	6.21±4.63	-0.032** 0.975	5.73±3.23	8.91±4.09	-1.699** 0.089

**Wilcoxon Signed Ranks Test (Z)

Statistically significant at $p < 0.05$

The D2 attention test was investigated using biophilic and non-biophilic workplace designs based on age groups. The CP values of the participants aged between 24 and 34 years were significantly higher in the non-biophilic environment (251.00) compared to the biophilic environment (220.53). However, participants aged 35 and older did not show higher TN or CP scores in the biophilic office. In fact, in the non-biophilic environment, participants aged 35 and older had lower TN scores (568.82) compared to the biophilic environment (623.00), but the CP scores in the biophilic environment (224.91) were not significantly different from those in the non-biophilic environment (209.36) (Table 7.26).

Table 7.27 and Table 7.28 compare participants' D2 attention test results by occupation in biophilic and non-biophilic settings and present between-group and within-group analyses.

7.27 Data Based on D2 Attention Test of Participants According to Profession in Biophilic and Non-Biophilic Environments (Between-Group Comparison)

Variables	Biophilic				Non-Biophilic			
	Academician	Student	Other	Test statistics; Sig. (p)	Academician	Student	Other	Test statistics; Sig. (p)
TN	Mean±SD	Mean±SD	Mean±SD	5.152** 0.076	Mean±SD	Mean±SD	Mean±SD	0.688** 0.709
	623.35±43.21	561.67±72.43	580.57±65.95		591.53±88.97	582.00±67.55	608.57±43.14	
E1	41.29±42.44	10.00±6.66	24.57±16.49	3.052** 0.217	42.35±37.59	10.33±7.71	26.00±26.63	4.836** 0.089
	42.44	6.66	16.49		37.59	7.71	26.63	
E2	10.76±38.21	24.17±52.04	0.14±0.38	10.262** 0.006	9.53±31.62	19.83±47.60	1.14±1.21	1.771** 0.412
	38.21	52.04	0.38		31.62	47.60	1.21	
TN-E	614.93±41.41	553.29±80.81	576.43±64.81	4.496** 0.106	583.11±88.06	576.00±76.14	604.14±43.31	0.390** 0.823
	41.41	80.81	64.81		88.06	76.14	43.31	
CP	214.29±64.10	232.33±41.93	232.43±21.42	0.621** 0.733	229.53±48.04	243.33±43.39	244.29±35.93	0.708** 0.702
	64.10	41.93	21.42		48.04	43.39	35.93	
FR	4.59±3.14	7.33±4.23	8.14±3.80	5.361** 0.069	6.47±4.29	9.17±4.92	7.29±5.09	1.580** 0.454
	3.14	4.23	3.80		4.29	4.92	5.09	

**Kruskal Wallis (H)

Statistically significant at $p < 0.05$

In the biophilic office, the E2 value of the D2 attention test showed a statistically significant difference according to the professions of the participants. The average E2 value is 24.17 for students, 10.76 for academicians, and 0.14 for participants from other professions (Table 7.27).

7.28 Data Based on D2 Attention Test of Participants According to Profession in Biophilic and Non-Biophilic Environments (Within-Group Comparison)

Variables	Academician			Student			Other		
	Biophilic	Non-Biophilic	Test statistics; Sig. (p)	Biophilic	Non-Biophilic	Test statistics; Sig. (p)	Biophilic	Non-Biophilic	Test statistics; Sig. (p)
TN	Mean±SD	Mean±SD	-2.244** 0.025	Mean±SD	Mean±SD	-1.214** 0.225	Mean±SD	Mean±SD	-1.014** 0.310
	623.35±43.21	591.53±88.97		561.67±72.43	582.00±67.55		580.57±65.95	608.57±43.14	
E1	41.29±42.44	42.35±37.59	-0.408** 0.683	10.00±6.66	10.33±7.71	-0.271** 0.786	24.57±16.49	26.00±26.63	-0.677** 0.498
	10.76±38.21	9.53±31.62		24.17±52.04	19.83±47.60		0.14±0.38	1.14±1.21	
E2	614.93±41.41	583.11±88.06	-2.154** 0.031	553.29±80.81	576.00±76.14	-1.153** 0.249	576.43±64.81	604.14±43.31	-1.014** 0.310
	214.29±64.10	229.53±48.04		232.33±41.93	243.33±43.39		232.43±21.42	244.29±35.93	
CP	4.59±3.14	6.47±4.29	-1.607** 0.108	7.33±4.23	9.17±4.92	-1.084** 0.279	8.14±3.80	7.29±5.09	-0.317** 0.751

**Wilcoxon Signed Ranks Test (Z)
Statistically significant at p < 0.05

When comparing the D2 test results based on the participants' professions, it was observed that the TN and TN-E scores of the academics decreased in the non-biophilic office. The average TN score for academics was 623.35 in the biophilic office, while it decreased to 591.53 in the non-biophilic office. Similarly, the average TN-E score for academics was 614.93 in the biophilic office, decreasing to 583.11 in the non-biophilic office (Table 7.28.)

Table 7.29 and Table 7.30 compare the D2 attention test results of participants with and without prior virtual reality (VR) experience in biophilic and non-biophilic environments, both between-group and within-group.

7.29 Data Based on D2 Attention Test of Participants According to Whether They Have Previous VR experience in Biophilic and Non-Biophilic Environments (Between-Group Comparison)

Variables	Biophilic			Non-Biophilic		
	No	Yes	Test statistics; Sig. (p)	No	Yes	Test statistics; Sig. (p)
TN	Mean±SD	Mean±SD	-1.364** 0.173	Mean±SD	Mean±SD	-1.728** 0.084
	613.21±52.46	580.00±67.58		596.74±90.74	588.18±37.91	
E1	30.11±36.91	32.91±32.92	-0.474** 0.63	31.84±34.95	32.64±31.71	-0.624** 0.532
	15.84±45.29	2.55±7.79		13.26±38.73	3.36±8.90	
E2	605.06±56.00	573.87±64.50	-1.442** 0.149	589.12±92.59	582.23±35.65	-1.829** 0.067
	219.95±61.48	225.91±33.77		242.63±48.90	223.82±31.77	
CP	5.16±3.37	7.36±4.15	-1.503** 0.212	5.95±4.29	9.36±4.37	-2.002** 0.045

**Mann Whitney U Test(Z)
Statistically significant at p < 0.05

In a non-biophilic environment, the mean FR of attention tests of participants who had previously experienced VR was 9.36, compared to 5.95 for participants who had not experienced VR before (Table 7.29).

7.30 Data Based on D2 Attention Test of Participants According to Whether They Have Previous VR experience in Biophilic and Non-Biophilic Environments (Within-Group Comparison)

Variables	No			Yes		
	Biophilic	Non-Biophilic	Test statistics; Sig. (p)	Biophilic	Non-Biophilic	Test statistics; Sig. (p)
	Mean±SD	Mean±SD		Mean±SD	Mean±SD	
TN	613.21±52.46	596.74±90.74	-1.042** 0.298	580.00±67.58	588.18±37.91	-0.51** 0.61
	30.11±36.91	31.84±34.95	-0.028** 0.977	32.91±32.92	32.64±31.71	0.00** 1.00
E1	15.84±45.29	13.26±38.73	-0.862** 0.389	2.55±7.79	3.36±8.90	-1.786** 0.074
	605.06±56.00	589.12±92.59	-0.885** 0.376	573.87±64.50	582.23±35.65	-0.445** 0.657
TN-E	219.95±61.48	242.63±48.90	-0.987** 0.324	225.91±33.77	223.82±31.77	-0.222** 0.824
	5.16±3.37	5.95±4.29	-0.856** 0.392	7.36±4.15	9.36±4.37	-1.233** 0.218
**Wilcoxon Signed Ranks Test (Z) Statistically significant at p < 0.05						

In the D2 attention test, there was no significant difference between the office designs and the participants with and without VR experience (Table 7.30).

Table 7.31 and Table 7.32 present within-group and between-group comparisons of D2 attention test performance of participants with biophilic design knowledge in biophilic and non-biophilic environments.

7.31 Data Based on D2 Attention Test of Participants According to Knowledge about biophilic design in Biophilic and Non-Biophilic Environments (Between-Group Comparison)

Variables	Biophilic				Non-Biophilic			
	Any knowledge	Little knowledge	Much knowledge	Test statistics; Sig. (p)	Any knowledge	Little knowledge	Much knowledge	Test statistics; Sig. (p)
	Mean±SD	Mean±SD	Mean±SD		Mean±SD	Mean±SD	Mean±SD	
TN	602.05±55.23	588.00±84.92	615.33±65.24	0.998** 0.754	604.64±55.32	600.80±26.66	500.67±183.19	0.477** 0.490
	29.91±34.69	47.80±43.23	12.33±9.50	0.712** 0.399	28.64±33.30	46.40±36.58	34.00±32.45	1.194** 0.274
E1	7.77±27.94	31.60±70.10	0.00±0.00	0.434** 0.510	7.14±25.34	26.40±57.37	0.00±0.00	0.119** 0.730
	595.20±57.82	574.84±75.95	613.32±65.43	0.764** 0.382	598.61±57.47	588.69±30.73	494.99±181.43	0.764** 0.382
TN-E	218.32±57.84	222.80±30.60	218.32±57.84	0.001** 0.975	243.27±44.51	216.40±44.35	212.67±26.63	1.974** 0.160
	6.27±3.72	6.40±4.10	3.00±3.46	0.025** 0.875	6.95±4.85	7.60±2.30	8.33±6.43	0.036** 0.850
**Kruskal Wallis (H) Statistically significant at p < 0.05								

The participants' biophilic design knowledge and D2 attention test scores did not differ meaningfully (Table 7.31).

7.32 Data Based on D2 Attention Test of Participants According to Knowledge about biophilic design in Biophilic and Non-Biophilic Environments (Within-Group Comparison)

Variables	Any knowledge			Little knowledge			Much knowledge		
	Biophilic	Non-Biophilic	Test statistics; Sig. (p)	Biophilic	Non-Biophilic	Test statistics; Sig. (p)	Biophilic	Non-Biophilic	Test statistics; Sig. (p)
TN	Mean±SD	Mean±SD	-0.161** 0.872	Mean±SD	Mean±SD	-0.405 0.686	Mean±SD	Mean±SD	-1.604** 0.109
	602.05±55.23	604.64±55.32		588.00±84.92	600.80±26.66		615.33±65.24	500.67±183.19	
E1	29.91±34.69	28.64±33.30	-0.720** 0.472	47.80±43.23	46.40±36.58	-0.405 0.686	12.33±9.50	34.00±32.45	-1.604** 0.109
	7.77±27.94	7.14±25.34		31.60±70.10	26.40±57.37		0.00±0.00	0.00±0.00	
E2	595.20±57.82	598.61±57.47	-0.453** 0.651	574.84±75.95	588.69±30.73	-0.405 0.686	613.32±65.43	494.99±181.43	-1.604** 0.109
	218.32±57.84	243.27±44.51		222.80±30.60	216.40±44.35		249.00±40.11	212.67±26.63	
CP	6.27±3.72	6.95±4.85	-1.949** 0.051	6.40±4.10	7.60±2.30	-0.135 0.893	3.00±3.46	8.33±6.43	-1.604** 0.109
FR			-0.722** 0.470			-0.962 0.336			-1.342** 0.180

**Wilcoxon Signed Ranks Test (Z)
Statistically significant at $p < 0.05$

According to Table 7.32, there is no statistical difference in D2 attention test scores among participants with different levels of biophilic design knowledge in the non-biophilic office.

Table 7.33 compares the State-Trait Anxiety Inventory (STAI) scores of participants in biophilic and non-biophilic environments and assesses the impact of these environments on anxiety levels.

Table 7.33 Data Based on Data based State Trait Anxiety Inventory (STA)

Variables	Biophilic			Non-Biophilic			Test statistics; Sig. (p)
	Mean	SD.	Min-max	Mean	SD.	Min-max	
State Trait Anxiety Inventory (STA)	31.70	6.47	21.00-53.00	37.67	8.79	21-60	-3.282** 0.001

**Wilcoxon Signed Ranks Test (Z)
Statistically significant at $p < 0.05$

Table 7.33 shows the data from the State Trait Anxiety Inventory. While the mean data in biophilic office was calculated as 31.70±6.47, it was calculated as 37.67±8.79 in non-biophilic office.

Table 7.34 and Table 7.35 provide a comparison of State-Trait Anxiety Inventory (STAI) scores according to gender in biophilic and non-biophilic environments and assess between-group and within-group differences.

Table 7.34 Data Based on State Trait Anxiety Inventory (STA) According to gender in Biophilic and Non-Biophilic Environments (Between-Group Comparison)

Variables	Biophilic			Non-Biophilic		
	Female	Male	Test statistics; Sig. (p)	Female	Male	Test statistics; Sig. (p)
	Mean±SD	Mean±SD		Mean±SD	Mean±SD	
STA	31.47±5.14	31.93±7.75	-0.166** 0.868	38.00±8.56	37.33±8.79	-0.332** 0.740

**Mann Whitney U Test(Z)

Statistically significant at $p < 0.05$

There was no significant difference in the anxiety tests between male and female participants in biophilic and non-biophilic offices (Table 7.34).

Table 7.35 Data Based on State Trait Anxiety Inventory (STA) According to gender in Biophilic and Non-Biophilic Environments (Within-Group Comparison)

Variables	Female			Male		
	Biophilic	Non-Biophilic	Test statistics; Sig. (p)	Biophilic	Non-Biophilic	Test statistics; Sig. (p)
	Mean±SD	Mean±SD		Mean±SD	Mean±SD	
STA	31.47± 5.14	38.00± 8.56	-2.350** 0.019	31.93± 7.75	37.33± 9.29	-2.335** 0.02

**Wilcoxon Signed Ranks Test (Z)

Statistically significant at $p < 0.05$

In the biophilic office environment, the average STA scores of female participants were 31.47 and 31.93 for male participants. In the non-biophilic office environment, these averages were 38.00 for female participants and 37.33 for male participants (Table 7.35).

Table 7.36 and Table 7.37 compare State-Trait Anxiety Inventory (STAI) scores by age groups in biophilic and non-biophilic settings and present between-group and within-group analyses.

Table 7.36 Data Based on State Trait Anxiety Inventory (STA) According to Age in Biophilic and Non-Biophilic Environments (Between-Group Comparison)

Variables	Biophilic			Non-Biophilic		
	24-34	35-	Test statistics; Sig. (p)	24-34	35-	Test statistics; Sig. (p)
	Mean±SD	Mean±SD		Mean±SD	Mean±SD	
STA	31.79±7.63	31.55±4.06	-0.173** 0.863	35.05±7.30	42.18±9.62	-1.896** 0.058

**Mann Whitney U Test(Z)

Statistically significant at $p < 0.05$

The State Trait Anxiety Inventory of the participants did not show a statistically significant difference according to age groups in the biophilic office design (Table 7.36).

Table 7.37 Data Based on State Trait Anxiety Inventory (STA) According to Age in Biophilic and Non-Biophilic Environments (Within-Group Comparison)

Variables	24-34			35-		
	Biophilic	Non-Biophilic	Test statistics; Sig. (p)	Biophilic	Non-Biophilic	Test statistics; Sig. (p)
STA	Mean±SD	Mean±SD	-2.313** 0.021	Mean±SD	Mean±SD	-2.346** 0.019
	31.79± 7.63	35.05± 7.30		31.55± 4.06	42.18± 9.62	

**Wilcoxon Signed Ranks Test (Z)

Statistically significant at $p < 0.05$

In Table 7.37, STA inventory scores of all participants aged 24-34 were higher in the non-biophilic office (35.05) than in the biophilic office (31.79). Similarly, participants aged 35 and over had higher scores in the non-biophilic office (42.18) compared to the biophilic office (7.37).

Table 7.38 and Table 7.39 compare State-Trait Anxiety Inventory (STAI) scores by professional groups in biophilic and non-biophilic environments and assess between-group and within-group differences.

Table 7.38 Data Based on State Trait Anxiety Inventory (STA) According to Profession in Biophilic and Non-Biophilic Environments (Between-Group Comparison)

Variables	Biophilic				Non-Biophilic			
	Academician	Student	Other	Test statistics; Sig. (p)	Academician	Student	Other	Test statistics; Sig. (p)
STA	Mean±SD	Mean±SD	Mean±SD	0.100** 0.752	Mean±SD	Mean±SD	Mean±SD	0.315** 0.575
	31.35± 7.22	29.50± 5.86	34.43± 4.54		37.59± 9.89	34.50± 5.47	40.57± 8.22	

**Kruskal Wallis (H)

Statistically significant at $p < 0.05$

There was no significant difference when the stress levels of the participants were evaluated according to their occupations in both environments (Table 7.38).

Table 7.39 State Trait Anxiety Inventory (STA) According to Profession in Biophilic and Non-Biophilic Environments (Within-Group Comparison)

Variables	Academician			Student			Other		
	Biophilic	Non-Biophilic	Test statistics; Sig. (p)	Biophilic	Non-Biophilic	Test statistics; Sig. (p)	Biophilic	Non-Biophilic	Test statistics; Sig. (p)
STA	Mean±SD	Mean±SD	-2.159** 0.031	Mean±SD	Mean±SD	-2.214** 0.027	Mean±SD	Mean±SD	-1.527** 0.127
	31.35± 7.22	37.59± 9.89		29.50± 5.86	34.50± 5.47		34.43± 4.54	40.57± 8.22	

**Wilcoxon Signed Ranks Test (Z)

Statistically significant at $p < 0.05$

As seen in Table 7.39, while the STA scores of academic participants increased from 31.35 in the biophilic office to 37.59 in the non-biophilic office, and the scores of student participants increased from 29.50 to 34.50, there was no significant change in the scores of participants from other profession groups.

Table 7.40 and Table 7.41 compare between-group and within-group State-Trait Anxiety Inventory (STAI) scores of participants with and without virtual reality (VR) experience in biophilic and non-biophilic settings.

Table 7.40 State Trait Anxiety Inventory (STA) According to whether they have previous VR experience in Biophilic and Non-Biophilic Environments (Between-Group Comparison)

Variables	Biophilic			Non-Biophilic		
	No	Yes	Test statistics; Sig. (p)	No	Yes	Test statistics; Sig. (p)
	Mean±SD	Mean±SD		Mean±SD	Mean±SD	
STA	31.21±	32.55±	-0.345** 0.730	35.95±	40.64±	-1.206** 0.228
	4.66	8.99		8.53	8.80	

**Mann Whitney U Test(Z)

Statistically significant at $p < 0.05$

There was no significant difference in the STA scores of the participants who had and did not experience VR in both environments (Table 7.40).

Table 7.41 State Trait Anxiety Inventory (STA) According to whether they have previous VR experience in Biophilic and Non-Biophilic Environments (Within-Group Comparison)

Variables	No			Yes		
	Biophilic	Non-Biophilic	Test statistics; Sig. (p)	Biophilic	Non-Biophilic	Test statistics; Sig. (p)
	Mean±SD	Mean±SD		Mean±SD	Mean±SD	
STA	31.21±	32.55±	-2.632** 0.008	35.95±	40.64±	-1.959** 0.050
	4.66	8.53		8.99	8.80	

**Wilcoxon Signed Ranks Test (Z)

Statistically significant at $p < 0.05$

STA scores of all participants, both with and without previous VR experience, were higher in the non-biophilic environment. For participants without VR experience, the average STA score was 31.21 in the biophilic office and 32.55 in the non-biophilic office. For participants with VR experience, the average STA score was 35.95 in the biophilic office and 40.64 in the non-biophilic (Table 7.41).

Table 7.42 State Trait Anxiety Inventory (STA) According to knowledge about biophilic design in Biophilic and Non-Biophilic Environments (Between-Group Comparison)

Variables	Biophilic				Non-Biophilic			
	Any knowledge	Little knowledge	Much knowledge	Test statistics; Sig. (p)	Any knowledge	Little knowledge	Much knowledge	Test statistics; Sig. (p)
	Mean±SD	Mean±SD	Mean±SD		Mean±SD	Mean±SD	Mean±SD	
STA	31.45±	32.20±	32.67±	0.522** 0.770	35.86±	43.40±	41.33±	3.529** 0.171
	6.90	5.36	6.81		8.70	8.99	4.93	

**Wilcoxon Signed Ranks Test (Z)

Statistically significant at $p < 0.05$

According to Table 7.42, there was no worthwhile relationship between the participants' biophilic design knowledge and State-Trait Anxiety Inventory (STA) values

Table 7.42 and Table 7.43 compare the State-Trait Anxiety Inventory (STAI) scores of participants with biophilic design knowledge in biophilic and non-biophilic environments and present between-group and within-group analyses.

Table 7.43 State Trait Anxiety Inventory (STA) According to knowledge about biophilic design in Biophilic and Non-Biophilic Environments (Within-Group Comparison)

Variables	Any knowledge			Little knowledge			Much knowledge		
	Biophilic	Non-Biophilic	Test statistics; Sig. (p)	Biophilic	Non-Biophilic	Test statistics; Sig. (p)	Biophilic	Non-Biophilic	Test statistics; Sig. (p)
	Mean±SD	Mean±SD		Mean±SD	Mean±SD		Mean±SD	Mean±SD	
STA	31.45±6.90	35.86±8.70	-2.315** 0.021	32.20±5.36	43.40±8.99	-2.023** 0.043	32.67±6.81	41.33±4.93	-1.342** 0.180

**Wilcoxon Signed Ranks Test (Z)

Statistically significant at $p < 0.05$

As seen in Table 7.43, when statistical differences in STA scores in both environments were evaluated based on the participants' knowledge of biophilic design, it was found that the STA scores of participants with no knowledge (31.45 in the biophilic office, 35.86 in the non-biophilic office) and little knowledge (32.20 in the biophilic office, 43.40 in the non-biophilic office) of biophilic design were significantly higher in the non-biophilic environment.

7.2.1 Findings regarding EEG data

In this section, the findings related to the spectral, spectral moment, time-domain, and nonlinear time-domain features of the collected EEG data are presented.

Table 7.44 presents a comparison of the EEG spectral sub-band characteristics of participants in biophilic and non-biophilic environments and evaluates the differences in delta, theta, alpha, beta, gamma waves and total power values.

7.44 Data based on Spectral Sub-Band EEG Features

Variables	Biophilic		Non-Biophilic		Test statistics; Sig. (p)
	Mean	SD.	Mean	SD.	
Delta	0.20	0.26	0.22	0.22	-1.162** 0.245
Theta	0.21	0.25	0.23	0.21	-1.368** 0.171
Alpha	0.20	0.26	0.25	0.23	-1.687** 0.092
Beta	0.22	0.24	0.37	0.25	-3.157** 0.002
Gamma	0.29	0.26	0.43	0.28	-2.519** 0.012
Total Power	0.21	0.24	0.26	0.22	-1.892** 0.058

**Wilcoxon Signed Ranks Test (Z)

Statistically significant at $p < 0.05$

In the comparative analysis of EEG spectral sub-band features, it was observed that beta (Mean=0.22 in biophilic, Mean=0.37 in non-biophilic) and gamma (Mean=0.29 in biophilic, Mean=0.43 in non-biophilic) frequencies exhibited lower levels in environments characterized as biophilic offices when contrasted with non-biophilic office settings (Table 7.44).

Table 7.45 and Table 7.46 examine between-group and within-group differences by comparing EEG spectral subband characteristics by gender in biophilic and non-biophilic environments.

7.45 Data based on EEG Spectral Subband EEG Features by gender (Between-Group Comparison)

Variables	Biophilic		Test statistics; Sig. (p)	Non-Biophilic		Test statistics; Sig. (p)
	Female Mean±SD	Male Mean±SD		Female Mean±SD	Male Mean±SD	
Delta	0.33±	0.09±	-2.640**	0.23±	0.21±	-0.457**
	0.333	0.09	0.008	0.20	0.24	0.000
Theta	0.34±	0.010±	-3.035**	0.24±	0.21±	-0.873**
	0.31	0.09	0.002	0.18	0.24	0.000
Alpha	0.33±	0.09±	-2.640**	0.27±	0.23±	-0.832**
	0.33	0.11	0.008	0.21	0.25	0.014
Beta	0.32±	0.13±	-1.954**	0.42±	0.33±	-1.289**
	0.30	0.12	0.051	0.24	0.26	0.085
Gamma	0.33±	0.25±	-0.457**	0.46±	0.40±	-0.686**
	0.31	0.20	0.647	0.29	0.27	0.080
Total Power	0.33±	0.10±	-2.578**	0.28±	0.24±	-0.915**
	0.31	0.09	0.010	0.19	0.24	0.032

**Wilcoxon Signed Ranks Test (Z)

Statistically significant at $p < 0.05$

According to table 7.45, analyses in the biophilic office design revealed that female participants had higher delta, theta, alpha and total power values in EEG measurements compared to male participants. In the biophilic environment, the mean values for the delta band were 0.33 for females and 0.09 for males. Similarly, for the theta band, mean values of 0.34 for females and 0.10 for males were recorded. Alpha band values were 0.33 for female participants and 0.09 for male participants. In terms of total power, the mean value for females was 0.33 and 0.10 for males. A similar situation was observed in the non-biophilic office environment; female participants had higher EEG power values than male participants. In this environment, the mean values for delta band were 0.23 for females and 0.21 for males; for theta band 0.24 for females and 0.21 for males; for alpha band 0.27 for females and 0.23 for males; and for total power 0.28 for females and 0.24 for males.

7.46 Data based on EEG Spectral Subband EEG Features by gender (Within-Group Comparison)

Variables	Female			Male		
	Biophilic	Non-Biophilic	Test statistics; Sig. (p)	Biophilic	Non-Biophilic	Test statistics; Sig. (p)
Delta	Mean±SD	Mean±SD		Mean±SD	Mean±SD	
	0.33±	0.22±	-0.847	0.08±	0.21±	-2.689**
Theta	0.33	0.20	0.397	0.09	0.24	0.007
	0.34±	0.24±	-0.659	0.10±	0.22±	-2.637**
Alpha	0.31	0.18	0.510	0.09	0.24	0.008
	0.33±	0.27±	-0.440	0.09±	0.23±	-2.741**
Beta	0.33	0.21	0.660	0.11	0.25	0.006
	0.32±	0.42±	-1.538	0.13±	0.33±	-3.051**
Gamma	0.30	0.24	0.124	0.12	0.25	0.002
	0.33±	0.46±	-1.224	0.25±	0.40±	-2.329**
Total Power	0.31	0.29	0.221	0.20	0.27	0.020
	0.32±	0.28±	-0.157	0.10±	0.24±	-2.741**
Total Power	0.31	0.19	0.875	0.09	0.24	0.006

**Wilcoxon Signed Ranks Test (Z)

Statistically significant at $p < 0.05$

Table 7.46 provides a comprehensive overview of spectral sub-band EEG features, encompassing delta, theta, alpha, beta, gamma, and total power, indicating that male participants displayed diminished levels within the biophilic office environment. The findings reveal a reduction in EEG power across all frequency bands for male participants in this environment. Specifically, the mean power in the delta band was 0.08 in the biophilic environment, lower than 0.21 in the non-biophilic environment. Similarly, the theta band showed a mean power of 0.10 in the biophilic environment, lower than 0.22 in the non-biophilic environment. In the alpha band, mean power in the biophilic environment was 0.09, compared to 0.23 in the non-biophilic environment. The beta band displayed a mean power of 0.13 in the biophilic environment, which was lower than 0.33 in the non-biophilic environment. For the gamma band, the biophilic environment recorded a mean of 0.25, lower than 0.40 in the non-biophilic environment. Lastly, the total power was also reduced in the biophilic environment (0.10) compared to the non-biophilic environment (0.24).

Table 7.47 and Table 7.48 examine EEG spectral subband characteristics by age groups in biophilic and non-biophilic environments, comparing between-group and within-group

7.47 Data based on EEG Spectral Subband EEG Features by Age (Between-Group Comparison)

Variables	Biophilic			Non-Biophilic		
	24-34 Mean±SD	35- Mean±SD	Test statistics; Sig. (p)	24-34 Mean±SD	35- Mean±SD	Test statistics; Sig. (p)
Delta	0,12±	0,34±	-1,356**	0,16±	0,31±	-1,743**
	0,11	0,38	0,175	0,13	0,30	0,081
Theta	0,14±	0,33±	-1,291**	0,18±	0,32±	-1,614**
	0,11	0,36	0,197	0,13	0,28	0,107
Alpha	0,12±	0,33±	-1,055**	0,19±	0,35±	-2,023**
	0,12	0,38	0,292	0,16	0,29	0,043
Beta	0,16±	0,32±	-1,356**	0,31±	0,47±	-1,485**
	0,15	0,33	0,175	0,22	0,27	0,138
Gamma	0,24±	0,38±	-1,873**	0,38±	0,51±	-1,420**
	0,24	0,27	0,061	0,28	0,26	0,156
Total	0,14±	0,33±	-1,270**	0,20±	0,36±	-1,593**
Power	0,12	0,35	0,204	0,15	0,28	0,111

**Wilcoxon Signed Ranks Test (Z)
Statistically significant at $p < 0.05$

In the non-biophilic office environment, it was found that participants over 35 years of age (0.35) had significantly higher values in alpha band power than participants aged 24-34 years (0.19) (Table 7.47).

7.48 Data based on EEG Spectral Subband EEG Features by Age (Within-Group Comparison)

Variables	24-34			35-		
	Biophilic Mean±SD	Non-Biophilic Mean±SD	Test statistics; Sig. (p)	Biophilic Mean±SD	Non-Biophilic Mean±SD	Test statistics; Sig. (p)
Delta	0,12±	0,16±	-1,087	0,34±	0,31±	-0,445
	0,11	0,13	0,277**	0,38	0,30	0,657**
Theta	0,14±	0,18±	-1,368	0,33±	0,32±	-0,445
	0,11	0,13	0,171**	0,36	0,28	0,657**
Alpha	0,12±	0,19±	-1,549	0,33±	0,35±	-0,445
	0,12	0,16	0,121**	0,38	0,29	0,657**
Beta	0,16±	0,31±	-3,139	0,32±	0,47±	-1,334
	0,15	0,22	0,002**	0,33	0,27	0,182**
Gamma	0,24±	0,38±	-2,286	0,38±	0,51±	-1,423
	0,24	0,28	0,022**	0,27	0,26	0,155**
Total	0,14±	0,20±	-2,133	0,33±	0,36±	-0,445
Power	0,12	0,15	0,033**	0,35	0,28	0,657**

**Wilcoxon Signed Ranks Test (Z)
Statistically significant at $p < 0.05$

In the analyses performed among the 24-34 age group participants, statistically significant differences were found between biophilic and non-biophilic environments. In beta band activity, the mean value in the non-biophilic environment (0.31) was significantly higher than in the biophilic environment (0.16). Similarly, in gamma band activity, the mean value in the non-biophilic environment (0.38) showed a significant difference compared to the biophilic environment (0.24) ($p = 0.022$). Also, in terms of

total EEG power, the mean value in the non-biophilic environment (0.20) was significantly higher than in the biophilic environment (0.14) (Table 7.48).

Table 7.49 and Table 7.50 present the comparison of EEG spectral subband characteristics in biophilic and non-biophilic environments according to occupational groups, with between-group and within-group analyses.

7.49 Data based on EEG Spectral Subband EEG Features by profession (Between-Group Comparison)

Variables	Biophilic				Non-Biophilic			
	Academician	Student	Other	Test statistics; Sig. (p)	Academician	Student	Other	Test statistics; Sig. (p)
	Mean±SD	Mean±SD	Mean±SD		Mean±SD	Mean±SD	Mean±SD	
Delta	0,30±	0,05±	0,08±	7,463	0,23±	0,11±	0,26±	2,162
	0,31	0,03	0,08	0,006**	0,18	0,10	0,35	0,141**
Theta	0,30±	0,06±	0,10±	6,711	0,24±	0,14±	0,27±	2,373
	0,29	0,04	0,10	0,010**	0,16	0,12	0,34	0,123**
Alpha	0,30±	0,06±	0,09±	4,869	0,27±	0,13±	0,30±	3,575
	0,32	0,04	0,08	0,027**	0,19	0,14	0,34	0,059**
Beta	0,30±	0,12±	0,11±	2,162	0,40±	0,29±	0,38±	1,103
	0,29	0,12	0,09	0,141**	0,22	0,24	0,34	0,294**
Gamma	0,36±	0,22±	0,18±	1,503	0,46±	0,36±	0,42±	0,593
	0,29	0,21	0,15	0,220**	0,28	0,26	0,31	0,441**
Total Power	0,30±	0,08±	0,10±	5,020	0,28±	0,17±	0,30±	2,593
	0,29	0,06	0,08	0,025**	0,17	0,15	0,34	0,107**

**Kruskal Wallis Test (H)
Statistically significant at $p < 0.05$

As seen in table 7.49, in the analyses conducted among occupational groups within the biophilic environment, significant differences were identified in EEG band power between academicians, students, and other occupational groups. In the delta band, the mean value for academicians (0.30) was significantly higher than that of students (0.05) and other occupational groups (0.08). Similarly, in the theta band, academicians displayed a mean value of 0.30, which was significantly higher compared to students (0.06) and other occupational groups (0.10). In the alpha band, the mean value for academicians (0.30) was also significantly higher than that of students (0.06) and other occupational groups (0.09) ($p = 0.027$). Furthermore, in terms of total EEG power, academicians had a significantly higher mean value (0.30) compared to students (0.08) and other occupational groups (0.10).

7.50 Data based on EEG Spectral Subband EEG Features by profession (Within-Group Comparison)

Variables	Academician			Student			Other		
	Biophilic	Non-Biophilic	Test statistics; Sig. (p)	Biophilic	Non-Biophilic	Test statistics; Sig. (p)	Biophilic	Non-Biophilic	Test statistics; Sig. (p)
	Mean±SD	Mean±SD		Mean±SD	Mean±SD		Mean±SD	Mean±SD	
Delta	0,30±	0,23±	-0,308	0,05±	0,11±	-1,992	0,08±	0,26±	-1,690
	0,31	0,18	0,758**	0,03	0,10	0,046**	0,08	0,35	0,091**
Theta	0,30±	0,24±	-0,071	0,06±	0,14±	-1,782	0,10±	0,27±	-1,521
	0,29	0,16	0,943**	0,04	0,12	0,075**	0,10	0,34	0,128**
Alpha	0,30±	0,27±	-0,095	0,06±	0,13±	-1,992	0,09±	0,30±	-1,859
	0,32	0,19	0,925**	0,04	0,14	0,046**	0,08	0,34	0,063**
Beta	0,30±	0,40±	-1,823	0,12±	0,29±	-1,992	0,11±	0,38±	-2,028
	0,29	0,22	0,068**	0,12	0,24	0,046**	0,09	0,34	0,043**
Gamma	0,36±	0,46±	-1,160	0,22±	0,36±	-1,782	0,18±	0,42±	-2,201
	0,29	0,28	0,246**	0,21	0,26	0,075**	0,15	0,31	0,028**
Total Power	0,30±	0,28±	-0,308	0,08±	0,17±	-1,992	0,10±	0,30±	-1,859
	0,29	0,17	0,758**	0,06	0,15	0,046**	0,08	0,34	0,063**

**Wilcoxon Signed Ranks Test (Z)
Statistically significant at $p < 0.05$

In the analyses, significant differences were found between biophilic and non-biophilic environments in terms of EEG band power for students and other occupational groups. In students, delta band activity was higher in the non-biophilic environment (0.11) compared to the biophilic environment (0.05). Similarly, alpha band activity increased in the non-biophilic environment (0.13) compared to the biophilic environment (0.06). In addition, beta band activity was higher in the non-biophilic environment (0.29) than in the biophilic environment (0.12). In other occupational groups, beta band (0.38) was higher in the non-biophilic environment compared to the biophilic environment (0.11) and gamma band activity (0.42) was higher in the non-biophilic environment compared to the biophilic environment (0.18) (Table 7.50)

Tables 7.51 and 7.52 present the EEG spectral subband characteristics of participants in biophilic and non-biophilic environments according to whether they had previous VR experience or not, with comparisons between and within groups.

Table 7.51 Data based on EEG Spectral Subband EEG Features by whether or not they have previously had VR experience (Between-Group Comparison)

Variables	Biophilic			Non-Biophilic		
	No	Yes	Test statistics; Sig. (p)	No	Yes	Test statistics; Sig. (p)
	Mean±SD	Mean±SD		Mean±SD	Mean±SD	
Delta	0,27±	0,07±	-2,303 0,021**	0,24±	0,18±	-0,366 0,715**
	0,31	0,05		0,25	0,15	
Theta	0,28±	0,09±	-1,958 0,050**	0,25±	0,19±	-0,495 0,621**
	0,29	0,06		0,24	0,14	
Alpha	0,28±	0,07±	-2,152 0,031**	0,26±	0,22±	-0,237 0,813**
	0,31	0,05		0,25	0,19	
Beta	0,29±	0,09±	-2,066 0,039**	0,39±	0,34±	-0,280 0,780**
	0,28	0,06		0,27	0,23	
Gamma	0,35±	0,18±	-1,593 0,111**	0,43±	0,44±	-0,129 0,897**
	0,29	0,13		0,29	0,27	
Total	0,28±	0,08±	-2,088	0,28±	0,23±	-0,516
Power	0,28	0,05	0,037**	0,24	0,17	0,606**

**Wilcoxon Signed Ranks Test (Z)

Statistically significant at $p < 0.05$

In the analyses conducted, significant differences were identified in EEG spectral subbands within the biophilic environment based on whether participants had previous VR experience. In the biophilic environment, delta band activity was found to be higher in participants without VR experience (0.27) compared to those with VR experience (0.07). Similarly, theta band activity was also higher in participants without VR experience (0.28) compared to those with VR experience (0.09). For the alpha band, participants without VR experience (0.28) showed higher activity compared to those with VR experience (0.07). Regarding the beta band, participants without VR experience (0.29) had higher values than those with VR experience (0.09). Additionally, total EEG power was found to be higher in participants without VR experience (0.28) compared to those with VR experience (0.08) (Table 7.51).

Table 7.52 Data based on EEG Spectral Subband EEG Features by whether or not they have previously had VR experience (Within-Group Comparison)

Variables	No			Yes		
	Biophilic	Non-Biophilic	Test statistics; Sig. (p)	Biophilic	Non-Biophilic	Test statistics; Sig. (p)
	Mean±SD	Mean±SD		Mean±SD	Mean±SD	
Delta	0,27±	0,24±	-0,282 0,778**	0,07±	0,18±	-2,490 0,013**
	0,31	0,25		0,05	0,15	
Theta	0,28±	0,25±	-0,040 0,968**	0,09±	0,19±	-2,49 0,013**
	0,29	0,24		0,06	0,14	
Alpha	0,28±	0,26±	-0,020 0,984**	0,07±	0,22±	-2,845 0,004**
	0,31	0,25		0,05	0,19	
Beta	0,29±	0,39±	-1,650 0,099**	0,09±	0,34±	-2,934 0,003**
	0,28	0,27		0,06	0,23	
Gamma	0,35±	0,43±	-0,966 0,334**	0,18±	0,44±	-2,599 0,009**
	0,29	0,29		0,13	0,27	
Total	0,28±	0,28±	-0,362	0,08±	0,23±	-2,624
Power	0,28	0,24	0,717**	0,05	0,17	0,009**

**Wilcoxon Signed Ranks Test (Z)

Statistically significant at $p < 0.05$

According to Table 7.52, significant differences were found between biophilic and non-biophilic environments for participants with VR experience. In the non-biophilic

environment, delta band activity (0.18) was significantly higher than in the biophilic environment (0.07). Similarly, theta band activity was significantly higher in non-biophilic environment (0.19) compared to biophilic environment (0.09). In terms of alpha band, a significant difference was found in the non-biophilic environment (0.22) compared to the biophilic environment (0.07). In addition, beta band activity was significantly higher in non-biophilic medium (0.34) than in biophilic medium (0.09). Gamma band activity was also significantly higher in the non-biophilic environment (0.44) than in the biophilic environment (0.18). Finally, total EEG power was significantly higher in the non-biophilic environment (0.23) compared to the biophilic environment (0.08).

Tables 7.53 and 7.54 show between-group and within-group comparisons of EEG spectral subband characteristics in biophilic and non-biophilic environments according to whether the participants had biophilic design knowledge or not.

Table 7.53 Data based on EEG Spectral Subband EEG Features by whether or not they have had biophilic design knowledge (Between-Group Comparison)

Variables	Biophilic				Non-Biophilic			
	Any Knowledge	Little Knowledge	Much Knowledge	Test statistics; Sig. (p)	Any Knowledge	Little Knowledge	Much Knowledge	Test statistics; Sig. (p)
	Mean±SD	Mean±SD	Mean±SD		Mean±SD	Mean±SD	Mean±SD	
Delta	0,20±	0,14±	0,30±	1,027	0,23±	0,20±	0,11±	1,282
	0,27	0,19	0,34	0,599**	0,23	0,26	0,02	0,527**
Theta	0,21±	0,14±	0,31±	1,327	0,24±	0,21±	0,14±	0,942
	0,26	0,18	0,28	0,515**	0,22	0,25	0,02	0,624**
Alpha	0,20±	0,14±	0,31±	1,217	0,27±	0,20±	0,18±	0,583
	0,27	0,20	0,33	0,544**	0,24	0,24	0,04	0,747**
Beta	0,23±	0,14±	0,24±	1,707	0,41±	0,29±	0,21±	2,546
	0,26	0,20	0,20	0,426**	0,24	0,34	0,05	0,280**
Gamma	0,32±	0,21±	0,18±	1,117	0,49±	0,32±	0,22±	3,102
	0,27	0,23	0,07	0,572**	0,26	0,35	0,13	0,212**
Total Power	0,21±	0,14±	0,28±	1,702	0,29±	0,22±	0,15±	1,491
	0,26	0,18	0,27	0,427**	0,22	0,27	0,01	0,474**

**Kruskal Wallis Test (H)

Statistically significant at $p < 0,05$

As seen in Table 7.53 there was no significant istatistical difference.

Table 7.54 Data based on EEG Spectral Subband EEG Features by whether or not they have had biophilic design knowledge (Within-Group Comparison)

Variables	Any knowledge			Little knowledge			Much knowledge		
	Biophilic	Non-Biophilic	Test statistics; Sig. (p)	Biophilic	Non-Biophilic	Test statistics; Sig. (p)	Biophilic	Non-Biophilic	Test statistics; Sig. (p)
Delta	0,20±	0,23±	-1,214	0,14±	0,20±	-1,214	0,30±	0,11±	-1,069
	0,27	0,23	0,225**	0,19	0,26	0,225**	0,34	0,02	0,285**
Theta	0,21±	0,24±	-1,214	0,14±	0,21±	-1,214	0,31±	0,14±	-1,069
	0,26	0,22	0,225**	0,18	0,25	0,225**	0,28	0,02	0,285**
Alpha	0,20±	0,27±	-1,753	0,14±	0,20±	-1,753	0,31±	0,18±	-0,535
	0,27	0,24	0,080**	0,20	0,24	0,080**	0,33	0,04	0,593**
Beta	0,23±	0,41±	-2,023	0,14±	0,29±	0,080	0,24±	0,21±	-0,535
	0,26	0,24	0,043**	0,20	0,34	0,043**	0,20	0,05	0,593**
Gamma	0,32±	0,49±	-0,730	0,21±	0,32±	-0,730	0,18±	0,22±	-0,535
	0,27	0,26	0,465**	0,23	0,35	0,465**	0,07	0,13	0,593**
Total Power	0,21±	0,29±	-1,355	0,14±	0,22±	-1,355	0,28±	0,15±	-0,535
	0,26	0,22	0,176**	0,18	0,27	0,176**	0,27	0,01	0,593**

**Wilcoxon Signed Ranks Test (Z)

Statistically significant at $p < 0.05$

According to the analysis in table 7.54, significant differences in beta band activity were found between biophilic and non-biophilic environments based on whether participants had "any" or "little" knowledge about biophilic design. In the "any knowledge" group, beta band activity in the non-biophilic environment (0.41) was significantly higher than in the biophilic environment (0.23) ($p = 0.043$). Similarly, in the "little knowledge" group, beta band activity in the non-biophilic environment (0.29) was significantly higher than in the biophilic environment (0.14).

Table 7.55 compares the mean values of EEG spectral moment characteristics in biophilic and non-biophilic environments.

Table 7.55 Data based on Spectral Moment EEG Features

Variables	Biophilic		Non-Biophilic		Test statistics; Sig. (p)
	Mean	SD.	Mean	SD.	
Moment 1	0.24	0.29	0.20	0.26	-0.267** 0.789
Moment 2	0.29	0.31	0.20	0.25	-0.813** 0.416
Moment 3	0.31	0.31	0.20	0.24	-1.594** 0.111

**Wilcoxon Signed Ranks Test (Z)

Statistically significant at $p < 0.05$

The examination of spectral moment EEG features did not reveal any statistically significant distinctions between office environments and the spectral moment EEG features of the participants (Table 7.55).

Table 7.56 evaluates the EEG spectral moment characteristics in biophilic and non-biophilic environments by gender through group comparisons.

Table 7.56 Data based on Spectral Moment EEG Features by gender (Between-Group Comparison)

Variables	Biophilic			Non-Biophilic		
	Female	Male	Test statistics; Sig. (p)	Female	Male	Test statistics; Sig. (p)
Moment1	0.31±	0.17±	-1.185**	0.22±	0.18±	-1.665**
	0.35	0.23	0.236	0.27	0.26	0.004
Moment2	0.37±	0.23±	-1.019**	0.22±	0.17±	-1.748**
	0.37	0.25	0.308	0.26	0.24	0.004
Moment3	0.28±	0.25±	-1.935**	0.23±	0.17±	-1.873**
	0.37	0.25	0.350	0.26	0.23	0.005

**Wilcoxon Signed Ranks Test (Z)

Statistically significant at $p < 0.05$

According to Table 7.56, it was observed that moment1, moment2 and moment3 values of female participants were significantly higher than male participants in non-biophilic office design. In particular, for moment1, the mean value for females was recorded as 0.22 and 0.18 for males. In moment2, the mean value for females was 0.22 and 0.17 for males, and this difference was statistically significant. Similarly, in moment3, the mean value for female participants was 0.23 and 0.17 for male participants, and this difference was also statistically significant.

Table 7.57 presents the values obtained in these environments for both genders with within-group comparisons.

Table 7.57 Data based on Spectral Moment EEG Features by gender (Within-Group Comparison)

Variables	Female			Male		
	Biophilic	Non-Biophilic	Test statistics; Sig. (p)	Biophilic	Non-Biophilic	Test statistics; Sig. (p)
Moment1	0.31±	0.22±	-0.220	0.17±	0.18±	-0.517**
	0.35	0.27	0.826	0.23	0.26	0.605
Moment2	0.37±	0.22±	-0.408	0.23±	0.17±	-0.672**
	0.37	0.26	0.683	0.25	0.24	0.501
Moment3	0.38±	0.23±	-0.910	0.25±	0.17±	-1.293**
	0.37	0.26	0.363	0.25	0.23	0.196

**Wilcoxon Signed Ranks Test (Z)

Statistically significant at $p < 0.05$

There is no statistical difference between office spaces and participants' gender (Table 7.57).

Tables 7.57 and 7.59 present EEG spectral moment features by age groups in both biophilic and non-biophilic environments, covering both between-group and within-group comparisons.

Table 7.58 Data based on Spectral Moment EEG Features by age (Between-Group Comparison)

Variables	Biophilic			Non-Biophilic		
	24-34	35-	Test statistics; Sig. (p)	24-34	35-	Test statistics; Sig. (p)
Moment1	0,21±	0,29±	-1,184	0,11±	0,35±	-1,851
	0,30	0,28	0,237**	0,12	0,37	0,064**
Moment2	0,25±	0,36±	-1,098	0,11±	0,34±	-1,937
	0,32	0,31	0,272**	0,10	0,35	0,053**
Moment3	0,27±	0,39±	-1,227	0,11±	0,34±	-1,786
	0,31	0,31	0,220**	0,09	0,34	0,074**

**Wilcoxon Signed Ranks Test (Z)

Statistically significant at $p < 0.05$

There is no statistical difference between office spaces and participants' age (Table 7.57).

Table 7.59 Data based on Spectral Moment EEG Features by age (Within-Group Comparison)

Variables	24-34			35-		
	Biophilic	Non-Biophilic	Test statistics; Sig. (p)	Biophilic	Non-Biophilic	Test statistics; Sig. (p)
Moment1	0,21±	0,11±	-0,966	0,29±	0,35±	-1,511
	0,30	0,12	0,334**	0,28	0,37	0,131**
Moment2	0,25±	0,11±	-1,791	0,36±	0,34±	-0,979
	0,32	0,10	0,073**	0,31	0,35	0,328**
Moment3	0,27±	0,11±	-2,133	0,39±	0,34±	-0,445
	0,31	0,09	0,033**	0,31	0,34	0,656**

**Wilcoxon Signed Ranks Test (Z)

Statistically significant at $p < 0.05$

Among the participants, the mean value of Moment 3 for those in the 24-34 age group was found to be higher in the biophilic office design than in the non-biophilic office design. The mean value for Moment 3 was recorded as (0.27) in the biophilic environment and (0.09) in the non-biophilic environment (Table 7.59)

Tables 7.60 and 7.61 present EEG spectral moment features categorized by profession, comparing values between groups and within each group in both biophilic and non-biophilic environments.

Table 7.60 Data based on Spectral Moment EEG Features by profession (Between-Group Comparison)

Variables	Biophilic				Non-Biophilic			
	Academician	Student	Other	Test statistics; Sig. (p)	Academician	Student	Other	Test statistics; Sig. (p)
Moment1	0,22±	0,21±	0,31±	0,011**	0,22±	0,09±	0,24±	0,020**
	0,29	0,34	0,29	0,916	0,29	0,05	0,29	0,889
Moment2	0,26±	0,28±	0,37±	0,207**	0,21±	0,11±	0,24±	0,000**
	0,30	0,37	0,34	0,649	0,28	0,05	0,27	1,000
Moment3	0,28±	0,32±	0,38±	0,276**	0,21±	0,12±	0,24±	0,200**
	0,29	0,36	0,35	0,599	0,27	0,07	0,27	0,889

**Kruskal Wallis Test (H)

Statistically significant at $p < 0.05$

There was no statistically significant difference between office environments and participants' professions (Table 7.60).

Table 7.61 Data based on Spectral Moment EEG Features by profession (Within-Group Comparison)

Variables	Academician			Student			Other		
	Biophilic	Non-Biophilic	Test statistics; Sig. (p)	Biophilic	Non-Biophilic	Test statistics; Sig. (p)	Biophilic	Non-Biophilic	Test statistics; Sig. (p)
Moment1	0,22±	0,22±	-0,639	0,21±	0,09±	-0,314	0,31±	0,24±	0,000
	0,29	0,29	0,523**	0,34	0,05	0,753**	0,29	0,29	1,000**
Moment2	0,26±	0,21±	-0,213	0,28±	0,11±	-1,153	0,37±	0,24±	-0,169
	0,30	0,28	0,831**	0,37	0,05	0,249**	0,34	0,27	0,866**
Moment3	0,28±	0,21±	-0,781	0,32±	0,12±	-1,572	0,38±	0,24±	-0,676
	0,29	0,27	0,435**	0,36	0,07	0,116**	0,35	0,27	0,499**

**Wilcoxon Signed Ranks Test (Z)
Statistically significant at p < 0.05

There was no statistically significant difference between office environments and participants' professions (Table 7.61).

Tables 7.62 and 7.63 provide a comparative analysis of EEG spectral moment features based on participants' previous VR experience in both biophilic and non-biophilic settings. The data evaluates between-group and within-group differences, highlighting potential variations in EEG responses linked to VR exposure history

Table 7.62 Data based on Spectral Moment EEG Features by whether or not they have previously had VR experience (Between-Group Comparison)

Variables	Biophilic			Non-Biophilic		
	No	Yes	Test statistics; Sig. (p)	No	Yes	Test statistics; Sig. (p)
Moment1	0,22±	0,27±	-0,689	0,21±	0,17±	-0,194
	0,29	0,31	0,491**	0,28	0,24	0,846**
Moment2	0,26±	0,35±	-0,882	0,20±	0,19±	-0,689
	0,30	0,34	0,378**	0,26	0,22	0,491**
Moment3	0,27±	0,38±	-0,968	0,20±	0,20±	-0,839
	0,29	0,34	0,333**	0,26	0,22	0,401**

**Kruskal Wallis Test (H)
Statistically significant at p < 0.05

There was no statistically significant difference between office environments and participants' previous VR experience (Table 7.62).

Table 7.63 Data based on Spectral Moment EEG Features by whether or not they have previously had VR experience (Within-Group Comparison)

Variables	No			Yes		
	Biophilic	Non-Biophilic	Test statistics; Sig. (p)	Biophilic	Non-Biophilic	Test statistics; Sig. (p)
Moment1	0,22±	0,21±	-0,785	0,27±	0,17±	-0,622
	0,29	0,28	0,433**	0,31	0,24	0,534**
Moment2	0,26±	0,20±	-0,141	0,35±	0,19±	-1,334
	0,30	0,26	0,888**	0,34	0,22	0,182**
Moment3	0,27±	0,20±	-0,765	0,38±	0,20±	-1,512
	0,29	0,26	0,445**	0,34	0,22	0,130**

**Wilcoxon Signed Ranks Test (Z)
Statistically significant at p < 0.05

There was no statistically significant difference between office environments and participants' previous VR experience (Table 7.63).

Tables 7.64 and 7.65 present data on spectral moment EEG features comparing participants with different levels of biophilic design knowledge in both biophilic and non-biophilic settings. These tables show both between-group and within-group differences in EEG spectral moments.

Table 7.64 Data based on Spectral Moment EEG Features by whether or not they have had biophilic design knowledge (Between-Group Comparison)

Variables	Biophilic				Non-Biophilic			
	Any Knowledge	Little Knowledge	Much Knowledge	Test statistics; Sig. (p)	Any Knowledge	Little Knowledge	Much Knowledge	Test statistics; Sig. (p)
Moment1	Mean±SD	Mean±SD	Mean±SD		Mean±SD	Mean±SD	Mean±SD	
	0,29±0,33	0,09±0,06	0,15±0,12	0,414 0,813**	0,21±0,30	0,11±0,10	0,24±0,14	1,506 0,471**
Moment2	0,34±0,35	0,14±0,09	0,20±0,20	0,435 0,805**	0,21±0,28	0,12±0,09	0,24±0,19	0,878 0,645**
	0,36±0,34	0,17±0,11	0,23±0,28	0,344 0,842**	0,21±0,27	0,13±0,08	0,25±0,22	0,747 0,688**

**Kruskal Wallis Test (H)

Statistically significant at $p < 0.05$

As seen in Table 7.64, these values indicate that there was no statistically significant difference between participants with and without biophilic design knowledge

Table 7.65 Data based on Spectral Moment EEG Features by whether or not they have had biophilic design knowledge (Within-Group Comparison)

Variables	Any knowledge			Little knowledge			Much knowledge		
	Biophilic	Non-Biophilic	Test statistics; Sig. (p)	Biophilic	Non-Biophilic	Test statistics; Sig. (p)	Biophilic	Non-Biophilic	Test statistics; Sig. (p)
Moment1	Mean±SD	Mean±SD		Mean±SD	Mean±SD		Mean±SD	Mean±SD	
	0,29±0,33	0,21±0,30	-0,405 0,686**	0,09±0,06	0,11±0,10	-0,405 0,686**	0,15±0,12	0,24±0,14	-1,069 0,285**
Moment2	0,34±0,35	0,21±0,28	-0,135 0,893**	0,14±0,09	0,12±0,09	-0,135 0,893**	0,20±0,20	0,24±0,19	-1,069 0,285**
	0,36±0,34	0,21±0,27	-0,135 0,893**	0,17±0,11	0,13±0,08	-0,135 0,893**	0,23±0,28	0,25±0,22	-0,535 0,593**

**Wilcoxon Signed Ranks Test (Z)

Statistically significant at $p < 0.05$

There was no statistically significant difference between office environments and whether or not they have had biophilic design knowledge (Table 7.65).

Table 7.66 compares time domain features of participants in biophilic vs. non-biophilic environments, using statistical tests to highlight differences.

Table 7.66 Data based on the Time domain Features of the participants in biophilic and non-biophilic environments

Variables	Biophilic			Non-Biophilic			Test statistics; Sig. (p)
	Mean	SD.	Min-max	Mean	SD.	Min-max	
Energy	0.15	0.30	0.00-1.00	0.18	0.22	0.00-1.00	-0.789** 0.430
Mean	0.65	0.16	0.00-1.00	0.62	0.23	0.00-1.00	-0.134** 0.894
Skewnes	0.59	0.23	0.00-1.00	0.24	0.16	0.00-1.00	-4.401** 0.00
Kurtosis	0.21	0.28	0.00-1.00	0.24	0.27	0.00-1.00	-1.450** 0.147
Activity	0.15	0.30	0.00-1.00	0.18	0.22	0.00-1.00	-0.774** 0.439
MAD	0.22	0.29	0.00-1.00	0.32	0.26	0.00-1.00	-1.265** 0.206
RMS	0.21	0.27	0.00-1.00	0.33	0.26	0.00-1.00	-1.862** 0.063
PTP	0.20	0.26	0.00-1.00	0.37	0.29	0.00-1.00	-2.844** 0.004
Mobility	0.46	0.25	0.00-1.00	0.40	0.23	0.00-1.00	1.366* 0.182
Complexity	0.41	0.24	0.00-1.00	0.53	0.28	0.00-1.00	-2.033* 0.051

*Paired sample t test (t)

**Wilcoxon Signed Ranks Test (Z)

Statistically significant at $p < 0.05$

The non-biophilic office environment demonstrated lower Skewness (biophilic: 0.59, non-biophilic: 0.24) and Complexity (biophilic: 0.41, non-biophilic: 0.53) values compared to the biophilic office. Conversely, within the biophilic office, reduced RMS (biophilic: 0.21, non-biophilic: 0.33) and PTP (biophilic: 0.20, non-biophilic: 0.37) values were observed (Table 7.66).

Table 7.67 and Table 7.68 provide both Between-Group Comparisons and Within-Group Comparisons of time-domain EEG features, examining variations between biophilic and non-biophilic environments, as well as differences based on gender.

Table 7.67 Data based on the Time domain Features of the participants in biophilic and non-biophilic environments according to their gender (Between-Group Comparison)

Variables	Biophilic			Non-Biophilic		
	Female	Male	Test statistics; Sig. (p)	Female	Male	Test statistics; Sig. (p)
Energy	Mean±SD	Mean±SD	-0.790** 0.440	Mean±SD	Mean±SD	-0.560** 0.595
	0.09±0.20	0.22±0.38		0.18±0.27	0.18±0.27	
Mean	0.67±0.08	0.63±0.21	-0.332** 0.744	0.61±0.25	0.63±0.22	-0.394** 0.713
	0.55±0.22	0.63±0.24		0.20±0.05	0.28±0.22	
Skewnes	0.29±0.34	0.14±0.18	-1.432** 0.161	0.22±0.22	0.25±0.31	-0.249** 0.806
	0.09±0.20	0.22±0.38		0.18±0.27	0.18±0.16	
Activity	0.20±0.21	0.24±0.36	-0.373** 0.713	0.30±0.29	0.34±0.23	-0.581** 0.567
	0.20±0.20	0.22±0.34		0.31±0.29	0.36±0.23	
MAD	0.20±0.21	0.19±0.31	-0.581** 0.461	0.31±0.30	0.36±0.28	-0.747** 0.461
	0.20±0.21	0.19±0.31		0.31±0.30	0.36±0.28	
RMS	0.20±0.40	0.19±0.51	-0.768** 0.461	0.34±0.45	0.40±0.35	-0.747** 1.179*
	0.21±0.40	0.31±0.51		0.30±0.45	0.28±0.35	
PTP	0.40±0.29	0.51±0.19	-1.139* 0.264	0.45±0.28	0.35±0.18	1.179* 0.248
	0.29±0.49	0.19±0.34		0.28±0.52	0.18±0.54	
Complexity	0.49±0.26	0.34±0.21	1.839* 0.077	0.52±0.24	0.54±0.32	-0.208* 0.837
	0.26±0.26	0.21±0.21		0.24±0.24	0.32±0.32	

* T Test (t)

**Mann Whitney U Test(Z)

Statistically significant at p < 0.05

Analysis of the spontaneous EEG waves of participants in both biophilic and non-biophilic environments, segregated by gender, reveals no statistically significant difference between the two office (Table 7.67).

Table 7.68 Data based on the Time domain Features of the participants in biophilic and non-biophilic environments according to their gender (Within-Group Comparison)

Variables	Female			Male		
	Biophilic	Non-Biophilic	Test statistics; Sig. (p)	Biophilic	Non-Biophilic	Test statistics; Sig. (p)
Energy	Mean±SD	Mean±SD	-1.306** 0.191	Mean±SD	Mean±SD	-0.283** 0.778
	0.09±0.20	0.18±0.27		0.22±0.38	0.18±0.16	
Mean	0.67±0.08	0.61±0.25	-0.227** 0.82	0.63±0.21	0.63±0.22	-0.114** 0.910
	0.55±0.22	0.20±0.20		0.63±0.24	0.28±0.22	
Skewnes	0.29±0.34	0.22±0.05	-3.351** <.001	0.14±0.18	0.25±0.31	-2.983** 0.003
	0.22±0.34	0.05±0.22		0.24±0.18	0.22±0.31	
Kurtosis	0.09±0.22	0.18±0.20	-1.350** 0.177	0.22±0.38	0.18±0.16	-0.283** 0.778
	0.22±0.20	0.20±0.30		0.38±0.24	0.16±0.34	
Activity	0.20±0.21	0.30±0.29	-1.193** 0.233	0.24±0.36	0.34±0.23	-0.454** 0.650
	0.21±0.20	0.29±0.31		0.36±0.22	0.23±0.36	
MAD	0.20±0.20	0.31±0.29	-1.307** 0.191	0.22±0.34	0.36±0.23	-1.193** 0.233
	0.20±0.20	0.29±0.29		0.34±0.34	0.23±0.23	
RMS	0.20±0.40	0.34±0.30	-1.591** 0.112	0.19±0.51	0.40±0.28	-2.605** 0.009
	0.21±0.40	0.30±0.30		0.31±0.51	0.28±0.35	
PTP	0.40±0.29	0.45±0.28	-0.751* 0.233	0.51±0.19	0.35±0.18	3.840* <.001
	0.29±0.49	0.28±0.28		0.19±0.34	0.18±0.54	
Complexity	0.49±0.26	0.52±0.24	-0.368* 0.359	0.34±0.21	0.54±0.32	-2.369* 0.016
	0.26±0.26	0.24±0.24		0.21±0.21	0.32±0.32	

*Paired sample t test (t)

**Wilcoxon Signed Ranks Test (Z)

Statistically significant at p < 0.05

The analysis of Time domain Features categorized by gender reveals distinct patterns in the two office environments. Within the biophilic office setting, male participants exhibited significantly lower PTP (biophilic: 0.19; non-biophilic: 0.40) and complexity (biophilic: 0.34; non-biophilic: 0.54) values, alongside an increase in mobility (biophilic: 0.51; non-biophilic: 0.35). Conversely, female participants demonstrated a notably lower Skewness value in the non-biophilic environment (biophilic: 0.63; non-biophilic: 0.28) (Table 7.68).

The tables presented below analyze the effects of biophilic and non-biophilic environments on participants' time space characteristics by age group. Table 7.69 evaluates the differences between age groups, while Table 7.70 analyzes the change between biophilic and non-biophilic environments within each age group.

Table 7.69 Data based on the Time domain Features of the participants in biophilic and non-biophilic environments according to their age (Between-Group Comparison)

Variables	Biophilic			Non-Biophilic		
	24-34	35-	Test statistics; Sig. (p)	24-34	35-	Test statistics; Sig. (p)
	Mean±SD	Mean±SD		Mean±SD	Mean±SD	
Energy	0.06±	0.31±	-1.968**	0.16±	0.21±	-0.560**
	0.17	0.41	0.049	0.17	0.29	0.575
Mean	0.64±	0.67±	-1.636**	0.54±	0.76±	-2.497**
	0.06	0.26	0.102	0.24	0.16	0.013
Skewnes	0.62±	0.54±	-0.882**	0.26±	0.22±	-0.474**
	0.21	0.27	0.378	0.19	0.09	0.636
Kurtosis	0.16±	0.29±	-1.765**	0.17±	0.35±	-0.882**
	0.24	0.33	0.078	0.16	0.37	0.378
Activity	0.06±	0.31±	-1.968**	0.16±	0.21±	-0.560**
	0.17	0.41	0.049	0.17	0.29	0.575
MAD	0.14±	0.37±	-1.593**	0.28±	0.38±	-0.581**
	0.19	0.38	0.111	0.25	0.27	0.561
RMS	0.13±	0.34±	-1.743**	0.28±	0.42±	-1.098**
	0.19	0.35	0.081	0.24	0.28	0.272
PTP.	0.13±	0.32±	-1.680**	0.29±	0.50±	-1.528**
	0.19	0.33	0.272	0.23	0.34	0.126
Mobility	0.45±	0.46±	-0.051*	0.39±	0.41±	-0.237*
	0.26	0.23	0.960	0.20	0.29	0.814
Complexity	0.45±	0.35±	1.176*	0.52±	0.55±	-0.355*
	0.26	0.22	0.250	0.30	0.25	0.725

* T Test (t)
**Mann Whitney U Test(Z)
Statistically significant at p < 0.05

The analysis of Time domain Features among participants in both biophilic and non-biophilic environments, categorized by age, revealed distinct trends. Specifically, within the biophilic office context, individuals aged over 35 demonstrated elevated levels of energy (mean = 0.31) and activity (mean = 0.31) compared to those aged 24-34, whose energy (mean = 0.06) and activity (mean = 0.06) values were significantly lower. Conversely, in the non-biophilic office environment, participants aged 35 and

older exhibited higher mean values (mean = 0.76) than their counterparts aged 24-34 (mean = 0.67) (Table 7.69).

Table 7.70 Data on the Time domain Features of the participants in biophilic and non-biophilic environments according to their age (Within-Group Comparison)

Variables	24-34		Test statistics; Sig. (p)	35-		Test statistics; Sig. (p)
	Biophilic Mean±SD	Non-Biophilic Mean±SD		Biophilic Mean±SD	Non-Biophilic Mean±SD	
Energy	0.06±	0.16±	-1.241**	0.31±	0.21±	-0.267**
	0.17	0.17	0.214	0.41	0.29	0.790
Mean	0.64±	0.54±	-0.604**	0.67±	0.76±	-0.800**
	0.06	0.24	0.546	0.26	0.16	0.424
Skewnes	0.62±	0.26±	-3.502**	0.54±	0.22±	-2.803**
	0.21	0.19	<.001	0.27	0.09	0.005
Kurtosis	0.16±	0.17±	-0.684**	0.29±	0.35±	-1.423**
	0.24	0.16	0.494	0.33	0.37	0.155
Activity	0.06±	0.16±	-1.241**	0.31±	0.21±	-0.357**
	0.17	0.17	0.214	0.41	0.29	0.721
MAD	0.14±	0.28±	-1.369**	0.37±	0.38±	-0.178**
	0.19	0.25	0.171	0.38	0.27	0.859
RMS	0.13±	0.28±	-1.650**	0.34±	0.42±	-0.712**
	0.19	0.24	0.099	0.35	0.28	0.477
PTP.	0.13±	0.29±	-2.214**	0.32±	0.50±	-1.785**
	0.19	0.23	0.027	0.33	0.34	0.074
Mobility	0.45±	0.39±	1.082*	0.46±	0.41±	0.826*
	0.26	0.20	0.294	0.23	0.29	0.428
Complexity	0.45±	0.52±	-0.928*	0.35±	0.55±	-2.035*
	0.26	0.30	0.365	0.22	0.25	0.069

*Paired sample t test (t)

**Wilcoxon Signed Ranks Test (Z)

Statistically significant at $p < 0.05$

The analysis of Time Domain Features by age groups, as shown in Table 7.70, highlights differences between the two office designs. Participants aged 24-34 had a lower Skewness value in the non-biophilic office (mean = 0.26) compared to the biophilic office (mean = 0.62) and a higher PTP value in the non-biophilic office (mean = 0.29) than in the biophilic office (mean = 0.13). This suggests changes in the signal's shape and amplitude in the non-biophilic environment. On the other hand, participants aged 35 and above showed a higher Skewness value in the biophilic office (mean = 0.54) compared to the non-biophilic office (mean = 0.22).

Table 7.71 and Table 7.72 provide a comparative analysis of the responses to biophilic and non-biophilic environments across different occupational groups in terms of time-domain variables, examining both within-group and between-group differences.

Table 7.71 Data on the the Time domain Features of the participants in biophilic and non-biophilic environments according to profession (Between-Group Comparison)

Variables	Biophilic				Non-Biophilic			
	Academician	Student	Other	Test statistics; Sig. (p)	Academician	Student	Other	Test statistics; Sig. (p)
Energy	0.16±	0.02±	0.26±	2.483**	0.18±	0.22±	0.16±	1.412**
	0.30	0.05	0.42	0.289	0.26	0.17	0.16	0.494
Mean	0.71±	0.66±	0.50±	9.366**	0.66±	0.47±	0.65±	3.889**
	0.11	0.01	0.24	0.009	0.23	0.25	0.20	0.143
Skewnes	0.52±	0.71±	0.64±	3.778**	0.25±	0.22±	0.23±	0.037**
	0.26	0.12	0.17	0.151	0.21	0.07	0.06	0.982
Kurtosis	0.20±	0.14±	0.30±	1.150**	0.24±	0.18±	0.27±	1.293**
	0.25	0.23	0.38	0.563	0.29	0.11	0.32	0.524
Activity	0.16±	0.02±	0.26±	2.483*	0.18±	0.22±	0.16±	1.412**
	0.30	0.05	0.42	0.289	0.26	0.17	0.16	0.494
MAD	0.22±	0.11±	0.34±	1.445**	0.30±	0.36±	0.32±	0.721**
	0.29	0.17	0.37	0.485	0.28	0.25	0.23	0.697
RMS	0.20±	0.11±	0.32±	1.552**	0.32±	0.36±	0.35±	1.083**
	0.26	0.18	0.36	0.460	0.28	0.24	0.24	0.582
PTP.	0.18±	0.11±	0.30±	1.614**	0.35±	0.36±	0.41±	0.730**
	0.24	0.20	0.35	0.446	0.30	0.23	0.33	0.694
Mobility	0.44±	0.58±	0.39±	1.121*	0.39±	0.48±	0.34±	0.556*
	0.23	0.30	0.24	0.341	0.27	0.22	0.15	0.580
Complexity	0.42±	0.41±	0.40±	0.019*	0.54±	0.38±	0.63±	1.299*
	0.25	0.30	0.22	0.981	0.24	0.25	0.37	0.289

* * One Way Anova (F)

**Kruskal Wallis (H)

The analysis of Time Domain Features characteristics across biophilic and non-biophilic environments, categorized by profession, revealed no statistically significant differences overall. However, a notable exception was found in the Mean value within the biophilic environment, where a statistically significant difference was observed among the occupational groups. Specifically, the Mean value for academicians in the biophilic environment was 0.71, compared to 0.66 for students and 0.50 for other occupational groups (Table 7.71).

Table 7.72 Data on the the Time domain Features of the participants in biophilic and non-biophilic environments according to profession (Within-Group Comparison)

Variables	Academician			Student			Other		
	Biophilic	Non-Biophilic	Test statistics; Sig. (p)	Biophilic	Non-Biophilic	Test statistics; Sig. (p)	Biophilic	Non-Biophilic	Test statistics; Sig. (p)
Energy	Mean±SD	Mean±SD		Mean±SD	Mean±SD		Mean±SD	Mean±SD	
	0.16±	0.18±	-0.465**	0.02±	0.22±	-1.782**	0.26±	0.16±	-0.338**
Mean	0.30	0.26	0.640	0.05	0.17	0.075	0.42	0.16	0.735
	0.71±	0.66±	-0.118**	0.66±	0.47±	-1.572**	0.50±	0.65±	-1.352**
Skewnes	0.11	0.23	0.906	0.01	0.25	0.116	0.24	0.20	0.176
	0.52±	0.25±	-2.947**	0.71±	0.22±	-2.201**	0.64±	0.23±	-2.366**
Kurtosis	0.26	0.21	0.003	0.12	0.07	0.028	0.17	0.06	0.018
	0.20±	0.24±	-1.254**	0.14±	0.18±	-0.734**	0.30±	0.27±	-0.338**
Activity	0.25	0.29	0.210	0.23	0.11	0.463	0.38	0.32	0.735
	0.16±	0.18±	-0.511**	0.02±	0.22±	-1.782**	0.26±	0.16±	-0.338**
MAD	0.30	0.26	0.609	0.05	0.17	0.075	0.42	0.16	0.735
	0.22±	0.30±	-0.828**	0.11±	0.36±	-1.572**	0.34±	0.32±	-0.169**
RMS	0.29	0.28	0.407	0.17	0.25	0.116	0.37	0.23	0.866
	0.20±	0.32±	-1.207**	0.11±	0.36±	-1.782**	0.32±	0.35±	-0.169**
PTP.	0.26	0.28	0.227	0.18	0.24	0.075	0.36	0.24	0.866
	0.18±	0.35±	-1.681**	0.11±	0.36±	-1.572**	0.30±	0.41±	-1.363**
Mobility	0.24	0.30	0.093	0.20	0.23	0.116	0.35	0.33	0.173
	0.44±	0.39±	0.850*	0.58±	0.48±	0.235*	0.39±	0.34±	0.266*
Complexity	0.23	0.27	0.408	0.30	0.22	0.470	0.24	0.15	0.532
	0.42±	0.54±	-1.561*	0.41±	0.38±	0.409*	0.40±	0.63±	0.060*
	0.25	0.24	0.138	0.30	0.25	0.817	0.22	0.37	0.121

*Paired sample t test (t)

**Wilcoxon Signed Ranks Test (Z)

Statistically significant at $p < 0.05$

In the examination of Time domain Features across different professional groups, including academics, students, and individuals from various other professions, significant differences were observed in Skewness scores, particularly among those situated in non-biophilic office environments. Academics exhibited a mean Skewness of 0.25 in non-biophilic settings, students had a mean of 0.22, and other professions recorded 0.23 in non-biophilic environments, all of which were significantly lower compared to their biophilic counterparts (Table 7.72).

Table 7.73 and Table 7.74 present data on the time-domain features of participants in biophilic and non-biophilic environments, categorized by their previous experience with virtual reality (VR), with a focus on both between-group and within-group comparisons.

Table 7.73 Data on the Data on the the Time domain Features of the participants in biophilic and non-biophilic environments, according to whether they have previous VR experience (Between-Group Comparison)

Variables	Biophilic			Non-Biophilic		
	No	Yes	Test statistics; Sig. (p)	No	Yes	Test statistics; Sig. (p)
Energy	Mean±SD	Mean±SD	-1.211** 0.226	Mean±SD	Mean±SD	-0.302** 0.763
	0.10±0.25	0.24±0.38		0.18±0.25	0.18±0.15	
Mean	0.67±0.08	0.61±0.24	-0.344** 0.731	0.61±0.26	0.64±0.19	-0.258** 0.796
	0.57±0.25	0.63±0.20		0.24±0.20	0.25±0.06	
Skewnes	0.22±0.31	0.19±0.22	-0.667** 0.505	0.24±0.27	0.23±0.27	-1.873** 0.061
	0.10±0.25	0.24±0.38		0.18±0.25	0.18±0.15	
Kurtosis	0.10±0.25	0.24±0.38	-1.211** 0.226	0.18±0.25	0.18±0.15	-0.302** 0.763
	0.18±0.25	0.30±0.35		0.31±0.28	0.33±0.23	
Activity	0.18±0.25	0.30±0.35	-1.012** 0.312	0.31±0.28	0.33±0.23	-0.452** 0.651
	0.25±0.33	0.34±0.23		0.17±0.23	0.28±0.33	
MAD	0.33±0.28	0.34±0.23	-0.990** 0.322	0.17±0.23	0.28±0.33	-0.560** 0.576
	0.16±0.23	0.25±0.31		0.36±0.29	0.38±0.29	
RMS	0.16±0.23	0.25±0.31	-0.969** 0.333	0.36±0.29	0.38±0.29	-0.366** 0.714
	0.43±0.25	0.50±0.25		0.37±0.26	0.45±0.19	
PTP.	0.43±0.25	0.50±0.25	-0.726* 0.474	0.37±0.26	0.45±0.19	-0.726* 0.387
	0.25±0.46	0.25±0.34		0.26±0.56	0.19±0.48	
Mobility	0.46±0.23	0.34±0.25	1.257* 0.219	0.56±0.26	0.48±0.32	1.257* 0.440
	0.23±0.25	0.25±0.25		0.26±0.32	0.32±0.32	
Complexity	0.23±0.25	0.25±0.25	0.219	0.26±0.32	0.32±0.32	0.440
	0.23±0.25	0.25±0.25		0.26±0.32	0.32±0.32	

* T Test (t)

**Mann Whitney U Test(Z)

Statistically significant at p < 0.05

As seen in Table 7.73, which shows Time Domain Features based on participants' prior experience with virtual reality (VR), found no significant differences between those with and without previous VR experience.

Table 7.74 Data based on the Data on the Time domain Features of the participants in biophilic and non-biophilic environments, according to whether they have previous VR experience (Within-Group Comparison)

Variables	No			Yes		
	Biophilic	Non-Biophilic	Test statistics; Sig. (p)	Biophilic	Non-Biophilic	Test statistics; Sig. (p)
Energy	Mean±SD	Mean±SD	-1.503** 0.133	Mean±SD	Mean±SD	-0.533** 0.594
	0.10±0.25	0.18±0.25		0.24±0.38	0.18±0.15	
Mean	0.67±0.08	0.61±0.26	-0.241** 0.809	0.61±0.24	0.64±0.19	-0.267** 0.790
	0.57±0.25	0.24±0.20		0.63±0.20	0.25±0.06	
Skewnes	0.22±0.31	0.24±0.27	-3.332** 0.001	0.19±0.22	0.23±0.27	-2.934** 0.003
	0.10±0.25	0.18±0.25		0.24±0.38	0.18±0.15	
Kurtosis	0.10±0.25	0.18±0.25	-1.368** 0.171	0.24±0.38	0.18±0.15	-0.800** 0.424
	0.18±0.25	0.31±0.28		0.30±0.35	0.33±0.23	
Activity	0.18±0.25	0.31±0.28	-1.491** 0.136	0.30±0.35	0.33±0.23	-0.533** 0.594
	0.25±0.17	0.28±0.33		0.35±0.28	0.23±0.34	
MAD	0.25±0.17	0.28±0.33	-1.409** 0.159	0.35±0.28	0.23±0.34	-0.178** 0.859
	0.17±0.23	0.33±0.28		0.28±0.33	0.34±0.23	
RMS	0.17±0.23	0.33±0.28	-1.932** 0.053	0.28±0.33	0.34±0.23	-0.356** 0.722
	0.23±0.16	0.28±0.36		0.33±0.25	0.23±0.38	
PTP.	0.16±0.23	0.36±0.29	-2.254** 0.024	0.25±0.31	0.38±0.29	-1.784** 0.074
	0.23±0.43	0.29±0.37		0.31±0.50	0.29±0.45	
Mobility	0.43±0.25	0.37±0.26	1.101* 0.286	0.50±0.25	0.45±0.19	0.770* 0.459
	0.25±0.46	0.26±0.56		0.25±0.34	0.19±0.48	
Complexity	0.46±0.23	0.56±0.26	-1.390* 0.181	0.34±0.25	0.48±0.32	-1.505* 0.163
	0.23±0.25	0.26±0.26		0.25±0.32	0.32±0.32	

*Paired sample t test (t)

**Wilcoxon Signed Ranks Test (Z)

Statistically significant at p < 0.05

The analysis of Time domain Features based on participants' prior exposure to virtual reality (VR) showed notable trends. Participants without previous VR experience had a lower mean Skewness value of 0.57 in non-biophilic office settings compared to 0.62 in biophilic environments. They also exhibited a higher mean PTP value of 0.20 in non-biophilic offices versus 0.13 in biophilic offices. Conversely, participants with VR experience had a mean Skewness value of 0.63 in non-biophilic environments, which was lower than the 0.71 recorded in biophilic settings (Table 7.74).

Table 7.75 and Table 7.76 present data on the time-domain features of participants in biophilic and non-biophilic environments, categorized by their level of knowledge about biophilic design, through both between-group and within-group comparisons.

Table 7.75 Data based on the the Time domain Features of the participants in biophilic and non-biophilic environments according to knowledge about biophilic design (Between-Group Comparison)

Variables	Biophilic				Non-Biophilic			
	Any knowledge	Little knowledge	Much knowledge	Test statistics; Sig. (p)	Any knowledge	Little knowledge	Much knowledge	Test statistics; Sig. (p)
	Mean±SD	Mean±SD	Mean±SD		Mean±SD	Mean±SD	Mean±SD	
Energy	0.11±	0.45±	0.01±	2.765**	0.16±	0.33±	0.08±	0.309**
	0.26	0.41	0.01	0.251	0.16	0.41	0.12	0.251
Mean	0.63±	0.73±	0.65±	1.227**	0.60±	0.70±	0.60±	1.248**
	0.15	0.22	0.02	0.541	0.26	0.09	0.14	0.536
Skewnes	0.62±	0.58±	0.38±	6.137**	0.25±	0.24±	0.18±	2.345**
	0.25	0.17	0.06	0.046	0.18	0.02	0.03	0.310
Kurtosis	0.27±	0.07±	0.06±	2.188**	0.28±	0.12±	0.13±	1.752**
	0.31	0.05	0.07	0.335	0.30	0.08	0.05	0.416
Activity	0.11±	0.45±	0.01±	2.765**	0.16±	0.33±	0.08±	0.309**
	0.26	0.41	0.01	0.251	0.16	0.41	0.12	0.857
MAD	0.19±	0.44±	0.08±	1.730**	0.31±	0.42±	0.23±	0.476**
	0.27	0.37	0.08	0.421	0.23	0.39	0.16	0.788
RMS	0.19±	0.36±	0.06±	2.011**	0.33±	0.42±	0.23±	0.455**
	0.28	0.31	0.06	0.366	0.24	0.39	0.16	0.796
PTP.	0.20±	0.27±	0.05±	1.097**	0.38±	0.40±	0.23±	0.565**
	0.28	0.22	0.04	0.578	0.29	0.38	0.14	0.754
Mobility	0.45±	0.44±	0.49±	0.037*	0.40±	0.34±	0.49±	0.347*
	0.24	0.17	0.47	0.964	0.19	0.29	0.47	0.710
Complexity	0.46±	0.26±	0.37±	1.468*	0.52±	0.56±	0.57±	0.079*
	0.24	0.20	0.32	0.248	0.28	0.28	0.37	0.925

* * One Way Anova (F)

**Kruskal Wallis (H)

Statistically significant at p < 0.05

The examination of time domain features among participants in biophilic and non-biophilic environments, categorized by knowledge about, revealed no statistically significant differences (Table 7.75).

Table 7.76 Data based on the the Time domain Features of the participants in biophilic and non-biophilic environments according to knowledge about biophilic design (Within-Group Comparison)

Variables	Any knowledge			Little knowledge			Much knowledge		
	Biophilic	Non-Biophilic	Test statistics; Sig. (p)	Biophilic	Non-Biophilic	Test statistics; Sig. (p)	Biophilic	Non-Biophilic	Test statistics; Sig. (p)
	Mean±SD	Mean±SD		Mean±SD	Mean±SD		Mean±SD	Mean±SD	
Energy	0.11±	0.16±	-1.234**	0.45±	0.33±	-0.944**	0.01±	0.08±	-1.604**
	0.26	0.16	0.217	0.41	0.41	0.345	0.01	0.12	0.109
Mean	0.63±	0.60±	-0.049**	0.73±	0.70±	-0.405**	0.65±	0.60±	0.000**
	0.15	0.26	0.961	0.22	0.09	0.686	0.02	0.14	1.000
Skewnes	0.62±	0.25±	-3.737**	0.58±	0.24±	-2.023**	0.38±	0.18±	-1.604**
	0.25	0.18	<.001	0.17	0.02	0.043	0.06	0.03	0.109
Kurtosis	0.27±	0.28±	-0.795**	0.07±	0.12±	-1.214**	0.06±	0.13±	-1.069**
	0.31	0.30	0.426	0.05	0.08	0.225	0.07	0.05	0.285
Activity	0.11±	0.16±	-1.234**	0.45±	0.33±	-0.944**	0.01±	0.08±	-1.342**
	0.26	0.16	0.217	0.41	0.41	0.345	0.01	0.12	0.180
MAD	0.19±	0.31±	-1.153**	0.44±	0.42±	-0.135**	0.08±	0.23±	-1.069**
	0.27	0.23	0.249	0.37	0.39	0.893	0.08	0.16	0.285
RMS	0.19±	0.33±	-1.705**	0.36±	0.42±	-0.135**	0.06±	0.23±	-1.604**
	0.28	0.24	0.088	0.31	0.39	0.893	0.06	0.16	0.109
PTP.	0.20±	0.38±	-2.242**	0.27±	0.40±	-1.483**	0.05±	0.23±	-1.604**
	0.28	0.29	0.025	0.22	0.38	0.893	0.04	0.14	0.109
Mobility	0.45±	0.40±	0.961*	0.44±	0.34±	1.669*	0.49±	0.49±	0.480*
	0.24	0.19	0.347	0.17	0.29	0.171	0.47	0.47	0.678
Complexity	0.46±	0.52±	-0.875*	0.26±	0.56±	-5.246*	0.37±	0.57±	-0.961*
	0.24	0.28	0.391	0.20	0.28	0.006	0.47	0.47	0.438

*Paired sample t test (t)

**Wilcoxon Signed Ranks Test (Z)

Statistically significant at p < 0.05

The analysis of EEG spontaneous time features, as shown in Table 7.76, indicated that participants without knowledge of biophilic design had Skewness value of 0.62 in non-biophilic environments, which is lower than the mean of 0.71 in biophilic environments. They also exhibited a higher PTP value of 0.20 in non-biophilic settings compared to 0.13 in biophilic settings. Additionally, participants with limited understanding of biophilic design showed an increased Complexity value of 0.46 in non-biophilic environments, compared to 0.26 in biophilic environments.

Table 7.77 compares the nonlinear characteristics exhibited by participants in biophilic and non-biophilic environments.

Table 7.77 Data based on Nonlinear Features of the participants in biophilic and non-biophilic environments

Variables	Biophilic			Non-Biophilic			Test statistics; Sig. (p)
	Mean	SD.	Min-max	Mean	SD.	Min-max	
HFD	0.59	0.25	0.00-1.00	0.60	0.24	0.00-1.00	-0.072** 0.943
KFD	0.38	0.27	0.00-1.00	0.29	0.24	0.00-1.00	-1.615** 0.106
HE	0.44	0.24	0.00-1.00	0.36	0.24	0.00-1.00	-2.221** 0.026
CD	0.78	0.24	0.00-1.00	0.65	0.25	0.00-1.00	-3.038** 0.002
AppEN	0.67	0.23	0.00-1.00	0.64	0.24	0.00-1.00	-0.956** 0.339
LFuzz	0.46	0.26	0.00-1.00	0.32	0.23	0.00-1.00	-3.029** 0.002
Perm	0.65	0.23	0.00-1.00	0.50	0.25	0.00-1.00	-3.211** 0.001
SpEn	0.61	0.24	0.00-1.00	0.55	0.25	0.00-1.00	-1.892** 0.058
LLE	0.45	0.25	0.00-1.00	0.60	0.27	0.00-1.00	-4.688* 0.000

*Paired sample t test (t)
**Wilcoxon Signed Ranks Test (Z)
Statistically significant at p < 0.05

According to Table 7.77, the analyses show that HE, CD and LFuzz values between biophilic and non-biophilic office environments are higher in the biophilic environment. While the average HE value was 0.44 in the biophilic environment, it was found to be 0.36 in the non-biophilic environment. Similarly, CD values were 0.78 in biophilic environment and 0.65 in non-biophilic environment and the difference was significant. For LFuzz, the mean value was 0.46 in biophilic environment and 0.32 in non-biophilic environment and this difference was statistically significant.

However, LLE values were found to be higher in non-biophilic environment. While the average LLE value was 0.45 in the biophilic environment, this value was 0.60 in the non-biophilic environment and this difference was quite significant.

Table 7.78 and Table 7.79 present data on nonlinear features of participants in biophilic and non-biophilic environments, categorized by gender. Table 7.77 focuses on between-group comparisons, analyzing differences between female and male participants, while Table 7.78 examines within-group comparisons, exploring changes in nonlinear features within each gender group between biophilic and non-biophilic environments.

Table 7.78 Data based on Nonlinear Features of the participants in biophilic and non-biophilic environments according to their gender (Between-Group Comparison)

Variables	Biophilic			Non-Biophilic		
	Female	Male	Test statistics; Sig. (p)	Female	Male	Test statistics; Sig. (p)
HFD	0.50±	0.67±	-1.494**	0.63±	0.56±	-0.643**
	0.29	0.16	0.137	0.22	0.27	0.539
KFD	0.45±	0.30±	-1.286**	0.30±	0.28±	-0.353**
	0.32	0.19	0.202	0.25	0.230	0.744
HE	0.47±	0.41±	-0.083**	0.37±	0.35±	-0.519**
	0.29	0.19	0.935	0.21	0.27	0.624
CD	0.73±	0.83±	-1.556**	0.68±	0.61±	-0.622**
	0.26	0.21	0.126	0.24	0.26	0.539
AppEN	0.60±	0.74±	-1.888**	0.67±	0.61±	-0.498**
	0.27	0.15	0.061	0.22	0.26	0.624
LFuzz	0.48±	0.43±	-0.456**	0.33±	0.32±	-0.104**
	0.31	0.21	0.653	0.27	0.19	0.935
Perm	0.56±	0.73±	-1.535**	0.53±	0.47±	-0.601**
	0.28	0.13	0.126	0.29	0.22	0.567
SpEn	0.53±	0.69±	-1.244**	0.58±	0.52±	-1.099**
	0.29	0.14	0.217	0.27	0.22	0.285
LLE	0.46±	0.45±	0.126*	0.58±	0.61±	-0.333*
	0.29	0.20	0.901	0.29	0.26	0.742

* T Test (t)
**Mann Whitney U Test(Z)
Statistically significant at p < 0.05

The analysis of Nonlinear Features among participants in both biophilic and non-biophilic environments, stratified by gender, indicated no istatistical difference between the two setting (Table 7.78).

Table 7.79 Data based on Nonlinear Features of the participants in biophilic and non-biophilic environments according to their gender (Within-Group Comparison)

Variables	Female			Male		
	Biophilic	Non-Biophilic	Test statistics; Sig. (p)	Biophilic	Non-Biophilic	Test statistics; Sig. (p)
HFD	0.50±	0.63±	-1.761**	0.67±	0.56±	-1.874**
	0.29	0.22	0.078	0.16	0.27	0.061
KFD	0.45±	0.30±	-1.477**	0.30±	0.28±	-0.454**
	0.32	0.25	0.140	0.19	0.23	0.650
HE	0.47±	0.37±	-1.363**	0.41±	0.35±	-1.676**
	0.29	0.21	0.173	0.19	0.27	0.094
CD	0.73±	0.68±	-0.785**	0.83±	0.61±	-3.237**
	0.26	0.24	0.433	0.21	0.26	0.001
AppEN	0.60±	0.67±	-1.224**	0.74±	0.61±	-2.480**
	0.27	0.22	0.221	0.15	0.26	0.013
LFuzz	0.48±	0.33±	-2.411**	0.43±	0.32±	-1.874**
	0.31	0.27	0.016	0.21	0.19	0.061
Perm	0.56±	0.53±	-0.847**	0.73±	0.47±	-3.294**
	0.28	0.29	0.397	0.13	0.22	<.001
SpEn.	0.53±	0.58±	-0.312**	0.69±	0.52±	-2.897**
	0.29	0.27	0.755	0.14	0.22	0.004
LLE	0.46±	0.58±	-2.598*	0.45±	0.61±	-4.101*
	0.29	0.29	0.021	0.20	0.26	0.001

*Paired sample t test (t)
**Wilcoxon Signed Ranks Test (Z)
Statistically significant at p < 0.05

According to Table 7.79, when EEG Spontaneous Nonlinear Features data were analysed according to gender, CD, AppEN, LFuzz, Perm and SpEn values were higher in the biophilic office environment compared to the non-biophilic environment among

male participants. The mean CD for male participants was 0.83 in the biophilic environment and 0.61 in the non-biophilic environment. AppEN mean was 0.74 in biophilic environment and 0.61 in non-biophilic environment. LFuzz value was 0.43 in biophilic environment and 0.32 in non-biophilic environment. The Perm value was 0.73 in the biophilic environment and 0.47 in the non-biophilic environment, while SpEn was 0.69 in the biophilic environment and 0.52 in the non-biophilic environment. However, the LLE value for male participants was lower in the biophilic environment and was found to be 0.45 in the biophilic environment and 0.61 in the non-biophilic environment.

Among female participants, only the LFuzz value was significantly higher in the biophilic environment. The mean LFuzz value for female participants was 0.48 in the biophilic environment and 0.33 in the non-biophilic environment.

Table 7.80 and Table 7.81 compare the nonlinear features of participants in biophilic and non-biophilic environments according to age groups. Table 7.79 examines differences between age groups, while Table 7.80 analyzes within-group changes for each age group.

Table 7.80 Data based on Nonlinear Features of the participants in biophilic and non-biophilic environments according to their age (Between-Group Comparison)

Variables	Biophilic			Non-Biophilic		
	24-34	35-	Test statistics; Sig. (p)	24-34	35-	Test statistics; Sig. (p)
	Mean±SD	Mean±SD		Mean±SD	Mean±SD	
HFD	0.59±0.27	0.59±0.21	-0.409**	0.62±0.22	0.56±0.28	-0.710**
KFD	0.35±0.27	0.43±0.27	-1.055**	0.21±0.13	0.42±0.32	-1.485**
HE	0.39±0.24	0.52±0.23	-1.270**	0.27±0.17	0.51±0.28	-2.647**
	0.79±0.24	0.74±0.25	-0.344**	0.69±0.21	0.57±0.31	-1.334**
CD	0.68±0.23	0.65±0.23	-0.409**	0.68±0.19	0.59±0.30	-0.968**
AppEN	0.42±0.25	0.52±0.27	-1.141**	0.26±0.15	0.44±0.28	-1.700**
LFuzz	0.61±0.26	0.71±0.16	-1.227**	0.46±0.26	0.55±0.24	-0.667**
Perm	0.58±0.28	0.67±0.15	-0.538**	0.54±0.25	0.57±0.25	-0.065**
SpEn.	0.51±0.25	0.35±0.22	1.727*	0.68±0.23	0.45±0.29	2.403*
LLE			0.095			0.023

* T Test (t)

**Mann Whitney U Test(Z)

Statistically significant at $p < 0.05$

As indicated in Table 7.80, participants over 35 years of age exhibited lower LLE values in the non-biophilic office. The mean LLE value for participants over 35 years

of age was 0.45 in the non-biophilic environment and 0.68 in the biophilic environment. In addition, HE values for participants over 35 years of age were 0.51 in the non-biophilic environment and 0.27 in the biophilic environment.

Table 7.81 Data based on Nonlinear Features of the participants in biophilic and non-biophilic environments according to their age (Within-Group Comparison)

Variables	24-34			35-		
	Biophilic Mean±SD	Non-Biophilic Mean±SD	Test statistics; Sig. (p)	Biophilic Mean±SD	Non-Biophilic Mean±SD	Test statistics; Sig. (p)
HFD	0.59±	0.62±	-0.241**	0.59±	0.56±	-0.622**
	0.27	0.22	0.809	0.21	0.28	0.534
KFD	0.35±	0.21±	-2.254**	0.43±	0.42±	-0.445**
	0.27	0.13	0.024	0.27	0.32	0.657
HE	0.39±	0.27±	-2.857**	0.52±	0.51±	-0.089**
	0.24	0.17	0.004	0.23	0.28	0.929
CD	0.79±	0.69±	-2.461**	0.74±	0.57±	-1.867**
	0.24	0.21	0.014	0.25	0.31	0.062
AppEN	0.68±	0.68±	-0.109**	0.65±	0.59±	-1.172**
	0.23	0.19	0.913	0.23	0.30	0.241
LFuzz	0.42±	0.26±	-2.809**	0.52±	0.44±	-1.274**
	0.25	0.15	0.005	0.27	0.28	0.203
Perm	0.61±	0.46±	-2.373**	0.71±	0.55±	-2.134**
	0.26	0.26	0.018	0.16	0.24	0.033
SpEn.	0.58±	0.54±	-1.308**	0.67±	0.57±	-1.334**
	0.28	0.25	0.191	0.15	0.25	0.182
LLE	0.51±	0.68±	-5.426*	0.35±	0.45±	-1.547*
	0.25	0.23	<.001	0.22	0.29	0.153

*Paired sample t test (t)

**Wilcoxon Signed Ranks Test (Z)

Statistically significant at p < 0.05

According to Table 7.81, the analysis of EEG signal characteristics for participants aged 24-34 years reveals that there is a decrease in KFD, HE, CD, LFuzz and Perm values in non-biophilic office designs. The mean value of KFD was 0.35 in the

biophilic environment, while this value decreased to 0.21 in the non-biophilic environment. Similarly, HE value was 0.39 in biophilic environment and 0.27 in non-biophilic environment. While the CD value was 0.79 in biophilic environment, it decreased to 0.69 in non-biophilic environment. While LFuzz value was 0.42 in biophilic environment, it decreased to 0.26 in non-biophilic environment. Perm value also decreased from 0.61 in biophilic environment to 0.46 in non-biophilic environment. However, the LLE value showed an increase in the non-biophilic environment; the LLE value was 0.51 in the biophilic environment and 0.68 in the non-biophilic environment.

Table 7.82 and Table 7.83 examine the nonlinear characteristics of participants in biophilic and non-biophilic environments with within and between group comparisons by occupational group.

Table 7.82 Data based on Nonlinear Features of the participants in biophilic and non-biophilic environments according to profession (Between-Group Comparison)

Variables	Biophilic				Non-Biophilic			
	Academician	Student	Other	Test statistics; Sig. (p)	Academician	Student	Other	Test statistics; Sig. (p)
HFD	0.58±	0.67±	0.53±	1.755**	0.57±	0.72±	0.56±	1.755**
	0.24	0.32	0.22	0.416	0.26	0.19	0.21	0.281
KFD	0.34±	0.41±	0.44±	1.196**	0.29±	0.23±	0.35±	0.742**
	0.27	0.31	0.25	0.550	0.28	0.09	0.23	0.69
HE	0.37±	0.34±	0.35±	0.497**	0.43±	0.46±	0.43±	0.090**
	0.27	0.11	0.27	0.780	0.24	0.17	0.33	0.956
CD	0.79±	0.81±	0.71±	0.342**	0.62±	0.77±	0.61±	2.203**
	0.23	0.22	0.31	0.843	0.28	0.12	0.24	0.332
AppEN	0.67±	0.75±	0.59±	2.475**	0.62±	0.75	0.60	2.606**
	0.22	0.25	0.23	0.290	0.27	0.15	0.22	0.272
LFuzz	0.41±	0.55±	0.48±	1.364**	0.30±	0.32±	0.39±	1.958**
	0.28	0.25	0.23	0.506	0.26	0.14	0.19	0.376
Perm	0.64±	0.75±	0.57±	1.453**	0.47±	0.64±	0.45±	2.755**
	0.20	0.23	0.30	0.484	0.27	0.19	0.23	0.252
SpEn.	0.62±	0.67±	0.55±	1.007**	0.55±	0.69±	0.44±	3.289**
	0.22	0.28	0.26	0.604	0.23	0.21	0.28	0.193
LLE	0.48±	0.36±	0.47±	0.537*	0.62±	0.52±	0.62±	0.317*
	0.25	0.17	0.32	0.591	0.30	0.19	0.29	0.731

* One Way Anova (F)

**Kruskal Wallis (H)

Statistically significant at $p < 0.05$

The analysis of nonlinear features in participants, shown in Table 7.82, indicates that there is no noticeable difference between biophilic and non-biophilic environments when grouped by profession.

Table 7.83 Data based on Nonlinear Features of the participants in biophilic and non-biophilic environments according to profession (Within-Group Comparison)

Variables	Academician			Student			Other		
	Biophilic	Non-Biophilic	Test statistics; Sig. (p)	Biophilic	Non-Biophilic	Test statistics; Sig. (p)	Biophilic	Non-Biophilic	Test statistics; Sig. (p)
HFD	0.58±	0.57±	-0.213**	0.67±	0.72±	-0.314**	0.53±	0.56±	-0.338**
	0.24	0.26	0.831	0.32	0.19	0.753	0.22	0.21	0.735
KFD	0.34±	0.29±	-0.686**	0.41±	0.23±	-1.782**	0.44±	0.35±	-0.845**
	0.27	0.28	0.492	0.31	0.09	0.075	0.25	0.23	0.398
HE	0.43±	0.37±	-1.704**	0.46±	0.34±	-1.572**	0.43±	0.35±	-0.507**
	0.24	0.27	0.088	0.17	0.11	0.116	0.33	0.27	0.612
CD	0.79±	0.62±	-2.896**	0.81±	0.77±	-0.734**	0.71±	0.61±	-1.183**
	0.23	0.28	0.004	0.22	0.12	0.463	0.31	0.24	0.237
AppEN	0.67±	0.62±	-0.738**	0.75±	0.75±	-0.105**	0.59±	0.60±	-0.507**
	0.22	0.27	0.460	0.25	0.15	0.917	0.23	0.22	0.612
LFuzz	0.41±	0.30±	-2.327**	0.55±	0.32±	-1.782**	0.48±	0.39±	-0.943**
	0.28	0.26	0.020	0.25	0.14	0.075	0.23	0.19	0.345
Perm	0.64±	0.47±	-2.58**	0.75±	0.64±	-0.943**	0.57±	0.45±	-1.992**
	0.20	0.27	0.010	0.23	0.19	0.345	0.30	0.23	0.046
SpEn.	0.62±	0.55±	-2.012**	0.67±	0.69±	-0.105**	0.55±	0.44±	-1.183**
	0.22	0.23	0.044	0.28	0.21	0.917	0.26	0.28	0.237
LLE	0.48±	0.62±	-3.232*	0.36±	0.52±	-2.222*	0.47±	0.62±	-2.282*
	0.25	0.30	0.005	0.17	0.19	0.077	0.32	0.29	0.063

*Paired sample t test (t)

**Wilcoxon Signed Ranks Test (Z)

Statistically significant at $p < 0.05$

The analysis of Nonlinear Features categorized by profession reveals significant differences across various measures. Among academic participants, CD (biophilic:

0.79, non-biophilic: 0.62), Lfuzz (biophilic: 0.41, non-biophilic: 0.30), Perm (biophilic: 0.64, non-biophilic: 0.47), and SpEn (biophilic: 0.62, non-biophilic: 0.55) values were notably lower in the non-biophilic office compared to the biophilic office. Conversely, the LLE value exhibited a marked increase in the non-biophilic environment (biophilic: 0.48, non-biophilic: 0.62), indicating greater signal complexity in the absence of biophilic design elements.

For participants in other occupational groups, a statistically significant difference was observed in Perm values, with higher values recorded in the biophilic office (biophilic: 0.57, non-biophilic: 0.45) (Table 7.83).

Table 7.84 and Table 7.85 present data on the nonlinear features of participants in biophilic and non-biophilic environments, categorized by previous virtual reality (VR) experience. Table 7.83 provides between-group comparisons of participants with and without prior VR experience, while Table 3.84 focuses on within-group comparisons to assess changes in nonlinear features for each group in different environments.

Table 7.84 Data based on Nonlinear Features of the participants in biophilic and non-biophilic environments, according to previous VR experience (Between-Group Comparison)

Variables	Biophilic			Non-Biophilic		
	No Mean±SD	Yes Mean±SD	Test statistics; Sig. (p)	No Mean±SD	Yes Mean±SD	Test statistics; Sig. (p)
HFD	0.57± 0.26	0.63± 0.24	-0.818** 0.413	0.56± 0.26	0.66± 0.19	-0.925** 0.355
	0.35±	0.43±	-0.796**	0.29±	0.29±	-0.280**
KFD	0.26	0.29	0.426	0.26	0.20	0.780
	0.43±	0.45±	-0.108**	0.36±	0.35±	-0.323**
HE	0.25	0.24	0.914	0.26	0.21	0.747
	0.76±	0.80±	-1.205**	0.64±	0.65±	-0.237**
CD	0.23	0.27	0.228	0.28	0.21	0.813
	0.65±	0.70±	-0.732**	0.61±	0.70±	-0.689**
AppEN	0.24	0.21	0.464	0.26	0.20	0.491
	0.41±	0.53±	-1.270**	0.30±	0.36±	-1.227**
LFuzz	0.25	0.28	0.204	0.25	0.18	0.220
	0.61±	0.71±	-1.098**	0.45±	0.58±	-1.356**
Perm	0.26	0.18	0.272	0.27	0.20	0.175
	0.58±	0.67±	-0.882**	0.52±	0.61±	-0.882**
SpEn.	0.26	0.19	0.378	0.26	0.22	0.378
	0.49±	0.39±	1.084*	0.63±	0.54±	0.812*
LLE	0.26	0.23	0.288	0.28	0.26	0.420

* T Test (t)

**Mann Whitney U Test(Z)

Statistically significant at $p < 0.05$

Investigation into Nonlinear Features, categorized by participants' prior experience with virtual reality (VR), indicated a lack of discernible disparity between individuals with and without previous VR exposure (Table 7.84).

Table 7.85 Data based on Nonlinear Features of the participants in biophilic and non-biophilic environments, according to previous VR experience (Within-Group Comparison)

Variables	No			Yes		
	Biophilic Mean±SD	Non-Biophilic Mean±SD	Test statistics; Sig. (p)	Biophilic Mean±SD	Non-Biophilic Mean±SD	Test statistics; Sig. (p)
HFD	0.57± 0.26	0.56± 0.26	-0.161** 0.872	0.63± 0.24	0.66± 0.19	-0.089** 0.929
	0.35± 0.26	0.29± 0.26	-0.926** 0.355	0.43± 0.29	0.29± 0.20	-1.334** 0.182
KFD	0.43± 0.25	0.36± 0.26	-1.630** 0.103	0.45± 0.24	0.35± 0.21	-1.423** 0.155
	0.76± 0.23	0.64± 0.28	-2.069** 0.039	0.80± 0.27	0.65± 0.21	-2.134** 0.033
CD	0.65± 0.24	0.61± 0.26	-0.686** 0.492	0.70± 0.21	0.70± 0.20	-0.800** 0.424
	0.41± 0.25	0.30± 0.25	-2.533** 0.011	0.53± 0.28	0.36± 0.18	-1.778** 0.075
LFuzz	0.61± 0.26	0.45± 0.27	-2.591** 0.010	0.71± 0.18	0.58± 0.20	-1.778** 0.075
	0.58± 0.26	0.52± 0.26	-1.469** 0.142	0.67± 0.19	0.61± 0.22	-0.978** 0.328
Perm	0.49± 0.26	0.63± 0.28	-4.080* 0.001	0.39± 0.23	0.54± 0.26	-2.482* 0.032
	LLE					

*Paired sample t test (t)

**Wilcoxon Signed Ranks Test (Z)

Statistically significant at p < 0.05

Table 7.85 presents the nonlinear features categorized by participants' prior experience with virtual reality (VR). Among individuals without previous VR exposure, those in non-biophilic office environments exhibited lower values in CD (non-biophilic: 0.64, biophilic: 0.76), LFuzz (non-biophilic: 0.30, biophilic: 0.41), and Perm (non-biophilic: 0.45, biophilic: 0.61) metrics compared to those in biophilic environments. However, the LLE metric was significantly higher in the non-biophilic setting (non-biophilic: 0.63, biophilic: 0.49).

Conversely, participants with prior VR experience exhibited lower CD (non-biophilic: 0.65, biophilic: 0.80) and value in non-biophilic office settings. In contrast, their LLE values were higher in non-biophilic environments (non-biophilic: 0.54, biophilic: 0.39).

Table 7.86 and Table 7.87 present data on the nonlinear features of participants in biophilic and non-biophilic environments according to their level of knowledge about biophilic design. Table 7.85 focuses on between-group comparisons among participants with any, little, or much knowledge, while Table 7.86 explores within-group differences, analyzing changes in nonlinear features for each level of knowledge between the two environments.

Table 7.86 Data on the Nonlinear Features of the participants in biophilic and non-biophilic environments according to profession (Between-Group Comparison)

Variables	Biophilic				Non-Biophilic			
	Any knowledge	Little knowledge	Much knowledge	Test statistics; Sig. (p)	Any knowledge	Little knowledge	Much knowledge	Test statistics; Sig. (p)
HFD	0.56±	0.67±	0.63±	0.448**	0.59±	0.60±	0.67±	0.236**
	0.27	0.09	0.32	0.799	0.25	0.20	0.33	0.889
KFD	0.41±	0.26±	0.32±	0.236**	0.29±	0.26±	0.33±	0.375**
	0.29	0.12	0.29	0.696	0.26	0.10	0.25	0.829
HE	0.48±	0.33±	0.30±	1.899**	0.38±	0.26±	0.34±	0.724**
	0.25	0.12	0.30	0.387	0.26	0.18	0.17	0.696
CD	0.75±	0.87±	0.82±	0.794**	0.61±	0.71±	0.81±	1.489**
	0.27	0.09	0.11	0.672	0.27	0.13	0.19	0.475
AppEN	0.63±	0.77±	0.74±	1.619**	0.61±	0.71±	0.75±	0.771**
	0.25	0.04	0.23	0.445	0.25	0.15	0.24	0.680
LFuzz	0.48±	0.39±	0.39±	0.636**	0.31±	0.33±	0.39±	0.504**
	0.27	0.16	0.41	0.728	0.24	0.11	0.31	0.777
Perm	0.64±	0.74±	0.53±	1.603**	0.49±	0.49±	0.59±	0.536**
	0.21	0.08	0.50	0.449	0.23	0.20	0.52	0.765
SpEn.	0.61±	0.69±	0.53±	0.688**	0.57±	0.47±	0.55±	0.757**
	0.22	0.11	0.49	0.709	0.21	0.26	0.51	0.685
LLE	0.43±	0.47±	0.56±	0.344*	0.59±	0.69±	0.53±	0.378*
	0.23	0.15	0.51	0.712	0.27	0.20	0.42	0.689

* One Way Anova (F)

**Kruskal Wallis (H)

Statistically significant at $p < 0.05$

Analysis of Nonlinear Features based on participants' knowledge about biophilic design yielded no statistically significant correlation (Table 7.86).

Table 7.87 Data on the Nonlinear Features of the participants in biophilic and non-biophilic environments according to profession (Within-Group Comparison)

Variables	Any knowledge			Little knowledge			Much knowledge		
	Biophilic	Non-Biophilic	Test statistics; Sig. (p)	Biophilic	Non-Biophilic	Test statistics; Sig. (p)	Biophilic	Non-Biophilic	Test statistics; Sig. (p)
HFD	0.56±	0.59±	-0.243**	0.67±	0.60±	-1.214**	0.63±	0.67±	-0.535**
	0.27	0.25	0.808	0.09	0.20	0.225	0.32	0.33	0.593
KFD	0.41±	0.29±	-1.867**	0.26±	0.26±	-0.135**	0.32±	0.33±	-0.535**
	0.29	0.26	0.062	0.12	0.10	0.893	0.29	0.25	0.593
HE	0.48±	0.38±	-2.208**	0.33±	0.26±	-1.214**	0.30±	0.34±	0.000**
	0.25	0.26	0.027	0.12	0.18	0.225	0.30	0.17	1.000
CD	0.75±	0.61±	-2.589**	0.87±	0.71±	-2.023**	0.82±	0.81±	0.000**
	0.27	0.27	0.010	0.09	0.13	0.043	0.11	0.19	1.000
AppEN	0.63±	0.61±	-0.643**	0.77±	0.71±	-1.214**	0.74±	0.75±	-0.447**
	0.25	0.25	0.520	0.04	0.15	0.225	0.23	0.24	0.655
LFuzz	0.48±	0.31±	-3.076**	0.39±	0.33±	-0.135**	0.39±	0.39±	-0.447**
	0.27	0.24	0.002	0.16	0.11	0.893	0.41	0.31	0.655
Perm	0.64±	0.49±	-2.743**	0.74±	0.49±	-2.023**	0.53±	0.59±	-1.342**
	0.21	0.23	0.006	0.08	0.20	0.043	0.50	0.52	0.180
SpEn.	0.61±	0.57±	-1.250**	0.69±	0.47±	-1.753**	0.53±	0.55±	-1.069**
	0.22	0.21	0.211	0.11	0.26	0.080	0.49	0.51	0.285
LLE	0.43±	0.59±	-4.565*	0.47±	0.69±	-3.167*	0.56±	0.53±	0.232*
	0.23	0.27	0.00	0.15	0.20	0.034	0.51	0.42	0.838

*Paired sample t test (t)

**Wilcoxon Signed Ranks Test (Z)

Statistically significant at $p < 0.05$

In examining nonlinear features relative to participants' familiarity with biophilic design principles, it was observed that individuals with little knowledge of biophilic design exhibited decreased values in HE (biophilic: 0.33, non-biophilic: 0.26), CD

(biophilic: 0.87, non-biophilic: 0.71), and LFuzz (biophilic: 0.39, non-biophilic: 0.33) within non-biophilic environments. Conversely, no significant change was noted in the SpEn metric. Interestingly, the LLE value increased in non-biophilic settings (biophilic: 0.36, non-biophilic: 0.52).

On the other hand, participants with any knowledge of biophilic design demonstrated lower values in CD (biophilic: 0.75, non-biophilic: 0.61) and Perm (biophilic: 0.64, non-biophilic: 0.49) when in non-biophilic environments. Additionally, the LLE value for this group was higher in non-biophilic environments (biophilic: 0.43, non-biophilic: 0.59) (Table 7.86).



8 Results

In this study, biophilic design elements were integrated into office spaces. In addition, thanks to the expert surveys, the biophilic design elements that are thought to be the most suitable for office spaces were determined and two designs, biophilic and non-biophilic offices, were modeled and visualized in accordance with these elements. Biophilic office and non-biophilic office designs were experienced by the subjects with VR headset and the physiological and wellbeing effects of these office environments on people were investigated.

In the light of the literature review conducted within the scope of the thesis study, biophilic design elements integrated into office designs are summarized in Table 8.1.

Table 8.1 Biophilic office design elements integrated into office designs

Nature in space	Visual connection with nature	Natural view	Production of Nature	Biomorphic forms and patterns	Spiral shapes
		Fire			Straight and Non-Right
		Pets			Angle forms
		Water			Organic forms
		Plant			Simulation (abstraction) of Natural Features
	Non-visual connection with nature	Aging, Change, natural materials bearing the traces of time		Objects reminding nature	Using fractal geometry
		Natural colours			Opposites that complement each other
		Natural sounds			Views reminding nature
		Sensory diversity			Objects reminding nature
	Dynamic and diffuse light	Diffuse light		Material connection with nature	Local and natural material
		Day light		Complexity and order	Balance of complexity and order
				Light	Light pool

According to the research conducted by Kellert, S. R. (2008), Ryan et al. (2014), and Cramer & Browning (2008), biophilic design elements suitable for integration into office environments are categorized primarily into two key sections: "Nature in Space" and "The Production of Nature." The "Nature in Space" category emphasizes the direct incorporation of natural elements into office settings alongside aesthetic connections to outdoor environments. This section is further divided into three main themes: non-visual connection to nature, dynamic and diffuse light, and visual connection to nature.

The topic of visual connection to nature is explored through five subcategories, including the integration of plants in office spaces, the inclusion of fire-related or fire-evocative features, the presence of pets, the use of water-inspired elements, and the

incorporation of greenery. Within non-visual connection to nature, several aspects are covered: the use of natural materials that age and change over time, the incorporation of natural colors, the application of natural sounds, and the promotion of sensory diversity in office settings. The dynamic and diffuse light theme focuses on the utilization of daylight and reflected light within workspaces.

The second section, "The Production of Nature," examines the indirect integration of natural components into office design, drawing inspiration from nature for design concepts. This section is divided into five subcategories: biomorphic form and pattern, objects that evoke nature, material connection to nature, complexity and order, and light.

The biomorphic form and pattern category highlights design features such as spiral, oval, and circular shapes, non-linear and non-right angle forms, abstractions of natural elements, fractal geometry, and contrasting color schemes (e.g., dark versus light) in office spaces. The objects that evoke nature theme includes the integration of landscapes or naturalistic objects into office designs. Material connection to nature emphasizes the use of local and natural materials. The complexity and order category focuses on achieving a harmonious balance within office designs, as overly empty spaces can evoke feelings of desolation, while overly complex areas may lead to anxiety and discomfort. Lastly, the light category involves the use of artificial lighting designed to mimic natural illumination within office spaces (Table 8.1).

The majority of respondents to the expert survey are women and young people. The proportion of postgraduate education is 56.4%, with a balance of master's and doctorate holders among those with education. 45.7% of the respondents have no knowledge about biophilic design, indicating that knowledge in this field is limited.

According to the results of the frequency analysis of the expert surveys conducted within the scope of the study, biophilic design elements **with an average of 3 and above** were integrated into the office designs. These design elements are summarized in Table 8.2 and the two main elements and 6 dimensions mentioned in Table 8.1 and the plant presence design element detailed in the survey study are summarized by integrating them with the frequency analysis of the survey study. However, the natural sounds and sensory diversity design elements mentioned in Table 8.1 were excluded

from the survey study as they also appeal to the auditory senses and cannot be visually modeled in three-dimensional design.

Table 8.2 Biophilic design elements to be integrated into office designs

				Mean*	Std. D.	
Nature in space	Visual connection with nature	View		Having a nature view	4,09	0,86
		Plant presence	Form	Round-shaped plants	3,1	1,09
				Scattered -shaped plants	3,12	1,19
			Texture	Rough textured plants	2,73	1,08
				Fine textured plants	3,08	1,05
			Size	Large sized plants	3,32	1,2
				Medium sized plants	3,35	1,02
				Small sized plants	3,37	1,11
			Colour	Green-leaved (monochrome) plants	3,84	1,05
		Multi-colored leafy plants		3,54	1,09	
	Flowering plants	3,54		1,19		
	Water		Presence of a design element to evoke water	3,62	1,2	
	Non-visual connection with nature	Aging, Change, natural materials bearing the traces of time		Using natural materials (wood, marble, etc.) that change over time	4,26	0,85
		Using natural colors		The use of color tones such as soil, green, blue, which reminds of nature	4,06	1,02
Dynamic and diffuse light	Reflective light		Using materials such as mirrors that reflect light	3,49	1,25	
	Daylight		Getting sunlight	4,89	0,41	
Production of Nature	Biomorphic forms and patterns	Oval and Round Shapes		Using oval and round forms	3,08	1,15
		Straight and Non-Right Angle forms		Using organic forms	3,41	1,22
		Simulation (abstraction) of Natural Features		Existence of patterns created by abstraction of animate and inanimate beings/shapes in nature	3,13	1,16
		Using fractal geometry		Using fractal (snowflake, leaf, cone) patterns found in nature	3,01	1,15
		Opposites that complement each other		Using contrasts that complement each other (such as using light and dark colors together)	3,81	1,08
	Objects reminding nature			Presence of objects depicting living things in nature (bird, tree, seashell)	3,12	1,17

Table 8.1 provides a summary of biophilic design elements identified through an expert survey and their integration into office designs. These elements are categorized under "**Nature in Space**" and "**The Production of Nature.**" In the "Nature in Space" category, the visual connection to nature includes features such as the presence of

natural views (Mean = 4.09), plants, and water-related elements. Among plant-related attributes, preferences are detailed by form, texture, size, and color, with green-leaved plants (Mean = 3.84) and medium to small-sized plants (Mean = 3.35–3.37) receiving notable emphasis. Water-inspired design elements also hold a moderate preference (Mean = 3.62). Non-visual connections to nature focus on the use of natural materials that age and change over time, such as wood and marble (Mean = 4.26), and natural colors like soil, green, and blue tones (Mean = 4.06). Dynamic and diffuse lighting, especially daylight, emerges as a critical factor, with daylight achieving the highest preference (Mean = 4.89).

The "Production of Nature" section highlights the indirect incorporation of nature into office designs. Biomorphic forms and patterns emphasize the use of organic shapes such as oval and round forms (Mean = 3.08) and non-linear, non-right-angle designs (Mean = 3.41). Abstract representations of natural features and fractal patterns derived from nature, such as snowflakes and leaves, are moderately valued (Mean = 3.13 and 3.01). The use of complementary contrasts, such as light and dark color pairings, is also appreciated (Mean = 3.81). Additionally, objects reminding nature, such as depictions of birds, trees, or seashells, are considered with moderate interest (Mean = 3.12). This table underscores the practical application of biophilic design elements to create office environments that foster a connection with nature and enhance user well-being.

When the survey results are analyzed based on the demographic characteristics of the participants, several significant findings emerge. A statistical difference in preferences for biophilic design elements was observed across genders. Specific elements, such as the presence of an object resembling or symbolizing fire, pyramid-shaped plants, column-shaped plants, round-shaped plants, rough-textured plants, plants of varying sizes (large, medium, and small), green-leaved (monochrome) plants, pet presence, the use of natural color tones (e.g., soil, green, blue), reflective materials like mirrors, access to sunlight, the use of oval and organic forms, and natural landscape paintings, were found to vary in importance between male and female participants. Among these, the presence of fire-resembling elements was rated as more important by male participants, whereas all other design elements were rated as more important by female participants, suggesting a higher overall significance placed on biophilic design elements by female participants.

A notable trend was identified regarding the presence of flowering plants, where the degree of importance attributed to this element decreased linearly with the age of the participants. Occupational differences also revealed distinct patterns in preferences. Landscape architects, for instance, emphasized the importance of nearly all design elements, with the exception of scattered-form plants. Psychiatrists prioritized the presence of natural landscape paintings and depictions of living beings in nature, highlighting these as the most critical design elements for their profession. Interestingly, participants from interior architecture and architecture disciplines placed comparatively less emphasis on incorporating natural design elements into built environments.

Finally, when the findings were examined based on participants' familiarity with biophilic design, a significant trend emerged: those with prior knowledge of biophilic design consistently valued these elements more highly than those without such knowledge. This indicates that awareness and understanding of biophilic principles positively influence the perceived importance of integrating natural elements into design. These results underscore the impact of gender, age, occupation, and expertise on preferences for biophilic design elements.

All findings from the experimental part of thesis are presented in the form of physical, psychometric, and EEG data in order to reveal the effects of biophilic and non-biophilic office designs on the participants.

It was found that the majority of the participants in the VR experiment were between the ages of 24 and 34, and academics were dominant in their occupational distribution. This shows that the research represents a young and academic audience.

When biophilic and non-biophilic office designs are evaluated according to the physical test results of the participants;

- A significant increase in the pulse rate of the participants was observed in the non-biophilic environment.
- The comparison between genders revealed that male participants working in non-biophilic offices exhibited higher systolic blood pressure levels than female participants.

- In terms of occupational groups, the lowest systolic blood pressure in biophilic office design was found in participants in other occupational groups, then in academicians, and the highest in students.
- In the non-biophilic environment, participants with no previous VR experience had lower levels of salivary cortisol than participants with VR experience.
- Participants with previous VR experience were found to have a higher heart rate in the biophilic office environment.

When biophilic and non-biophilic office designs are evaluated according to the psychometric results of the participants;

- Male participants in the biophilic environment were found to have higher E2 values, i.e. carelessness errors, than female participants.
- In the biophilic environment, CP values of female and male participants, i.e. general test achievement, were found to be lower than in the non-biophilic environment.
- In the biophilic environment, the E1, i.e. selective attention, of participants aged 35 years and above is higher than the age groups between 24-34 years. In the non-biophilic environment, the CP value, i.e. the general achievement of the participants in the 24-34 age group is higher, while the CP value of the participants over 35 years of age is lower. Participants over 35 years of age have higher TN, i.e. the capacity to sustain attention, and TN-E, i.e. the quality of performance and the balance between psychomotor speed and selective attention. The CP value of participants aged 24-35 years was higher in the non-biophilic environment and lower in the biophilic environment. The fact that this value was lower in the biophilic office indicates instability in psychomotor speed, distraction and low quality in overall test performance. In the light of this information, it can be concluded that the increase in the attention level of participants aged 35 years and over is positively affected by the biophilic designed office.

- In the biophilic environment, E2, that is, the value of making mistakes, was found to be highest in students, then in academics and least in participants from other occupational groups. It was found that the TN value of academicians was higher in the biophilic environment, that is, their attention was distracted more frequently, but the TN-E value was higher in the biophilic environment, that is, the overall test success was higher. This shows that especially academicians' attention is better in the biophilic office environment.
- In non-biophilic office environments, the FR result was higher for participants who had previous VR experience, while it was lower for those who had not. In other words, participants with VR experience have lower motivation in a biophilic environment.
- In the biophilic office environment, participants were found to have lower anxiety levels.
- The stress levels of female participants and male participants were lower in the Biophilic office environment than in the non-biophilic office environment.
- Participants between the ages of 24-34 and participants over the age of 35 had lower stress levels in the biophilic office.
- While the stress level of academicians and students was lower in biophilic office design, no statistically significant change was found in the stress level of participants in other occupational groups.
- Participants with and without previous VR experience all had lower stress levels in the biophilic office design.
- Participants who had no and little knowledge about biophilic design were found to have lower stress levels in the biophilic office environment, while the change in stress in the offices of those with a lot of knowledge was not statistically significant.

When evaluated according to the findings of EEG data of the participants of biophilic and non-biophilic office designs;

- Beta and Gamma waves of the participants were lower in the biophilic office environment than in the non-biophilic environment. High Beta waves are associated with stress, anxiety and mental intensity, while high gamma waves are associated with high cognitive processing. The EEG data were measured in the VR experience without giving any task to the participants, only the effect of the environment was measured. In this context, it can be said that biophilic office design has a calming and stress-reducing effect on the participants.
- In the biophilic environment, female participants had higher Delta, Theta, Alpha and total power values than male participants. In the non-biophilic office, female participants' Delta, Theta and total power values were also higher than male participants. Female participants responded differently from male participants in both office designs. In addition, women's mean Delta, Theta and total power values in the biophilic office were higher than in the non-biophilic office. In this context, considering that both offices were well-designed spaces with an interior designer, it can be concluded that female participants' brains are less stressed in well-designed spaces than male participants and that they experience less stress in the biophilic office than in the non-biophilic office.
- It was found that Delta, Theta, Alpha, Beta, Gamma and total power values were higher in male participants in non-biophilic environment. It was observed that the biophilic environment created a more balanced brain activity by reducing stress in male participants. Women were more positively affected by the well-designed environment than men.
- In the non-biophilic environment, the alpha value of the participants over the age of 35 was higher than the participants between the ages of 24-34. In this environment, it can be concluded that participants over the age of 35 are less stressed and anxious than participants between the ages of 24-34.
- It was found that beta, gamma and total power values of the participants between the ages of 24-34 were lower in the biophilic environment. This may be associated with low stress.

- In the biophilic environment, delta, theta, alpha and total power values were found to be the highest in academics, followed by participants belonging to other professional groups and the lowest in students. In this context, it can be said that the biophilic office has the most positive effects on academics and they experience the most relaxation and mental clarity. This is thought to be related to the habit of being in an office environment.
- The alpha, beta and total power values of the students were lower in the biophilic environment. It can be thought that students experience more relaxation and less mental pressure in the biophilic environment than in the non-biophilic environment. Beta and gamma waves of people in other occupational groups were lower in the biophilic office, suggesting that the biophilic environment has more positive effects on other occupational groups.
- In the biophilic office design, the delta, Theta, Alpha, Beta and total power values of the participants who had not experienced VR before were higher than those of the participants who had experienced VR before. Biophilic office design created higher mental excitement and attention in participants who had not experienced VR before, while those who had experienced VR experienced this environment as a more calm and relaxing experience. This is thought to be due to the fact that participants who have experienced VR are used to this experience before.
- It was found that the Delta, Theta, Alpha, Beta, Gamma and Total Power values of participants with previous VR experience were lower in the biophilic office design than in the non-biophilic office design. This finding suggests that participants with VR experience experienced less mental excitement, lower stress, and more relaxation in the biophilic environment. Biophilic designs may have offered a more familiar or relaxing environment for participants who were familiar with VR technologies. Furthermore, participants' prior VR experience may have allowed them to perceive the differences between the two environments more clearly.
- Participants who had no or little knowledge about biophilic design had lower beta values in biophilic office design compared to non-biophilic office design.

These results show that biophilic design provides mental relaxation and reduces stress levels in participants who have little or no knowledge about biophilic design. In participants who were knowledgeable about the subject, it is thought that the situation of comparing environments may have caused more stress and excitation in the brain.

- Participants aged 24-34 years were found to have higher moment3 values in the biophilic environment. Higher moment3 values in the biophilic environment indicate that participants in the 24-34 age group show a certain asymmetric distribution of neural activity in this environment. This may indicate that participants in this age group show more activity of a certain brain region than others in the biophilic environment or that neural excitation leads to an imbalance. This suggests that the biophilic environment may lead to different emotional and mental responses in this age group. The response of individuals in this age group to biophilic environments may include both relaxation and some forms of mental excitation.
- In the biophilic office design, the skewness value of the participants was higher, while the RMS, PTP, and Complexity values were lower than the non-biophilic office design. In this context, while the participants concentrated on specific mental processes, their overall brain activity became more balanced and less energy consuming. This suggests that the biophilic office generally reduces the stress levels of the participants and provides mental relaxation.
- Skewness value of female participants was higher in biophilic office design, while it was lower in non-biophilic office design. Male Participants' PTP and complexity values were lower in the biophilic office environment, while Mobility value was higher. This suggests that the biophilic office may have more strongly triggered certain mental processes (e.g. relaxation, concentration or emotional regulation) in women. Female participants may have used their brain activity more intensively in certain areas in the biophilic environment, increasing the asymmetry. The lower PTP in men indicates that their brain activity is more balanced and stable in the biophilic environment. The biophilic office may have created less mental fluctuations and a more stable mental state in male participants. Complexity refers to the variability and complexity of

brain activity. The lower complexity in men in the biophilic environment indicates that their brain activity is more organized and simple. This suggests that the biophilic office has a more calming and regulating effect on men. Mobility refers to the variability and flexibility of the brain's neural activity. The higher Mobility value in male participants in the biophilic environment indicates that they exhibit a more dynamic, flexible and adaptive brain activity in the biophilic office. These findings suggest that biophilic office design has different but generally positive effects on both male and female participants. The biophilic environment induced a more stable and flexible mental state in men, whereas it triggered a more pronounced and asymmetrical brain activity in women.

- In the biophilic office design, the energy and activity values of the participants aged 24-34 are lower, while those aged 35+ are higher. In the non-biophilic environment, the mean value of the participants between 24-34 years of age is lower in participants over 35 years of age. The lower Energy and Activity values of younger participants may indicate that this age group expends less energy in the biophilic environment and is in a calmer, less active mental state. Similarly, the lower mean value in the non-biophilic environment can be explained as the result of a similar effect.
- Participants aged 24-34 years had a higher skewness value in the biophilic environment and a lower PTP value in the non-biophilic environment. Similarly, the skewness value was found to be higher in the biophilic environment than in the non-biophilic environment in participants aged 35 years and older. In both age groups, biophilic office design may have increased mental balance and created a more relaxing effect.
- It was found that the mean value in the biophilic office was highest in academics, more moderate in students and lowest in other occupational groups. The biophilic environment may have had the greatest impact on academics and increased their mental performance. This indicates that academics are more cognitively stimulated and focused. Students may have benefited moderately from the biophilic environment and may have experienced some relaxation and increased mental performance. Other professional groups may have

experienced less mental excitement and more relaxation in the biophilic environment, leading to lower mean values. The effects of biophilic environments on mental performance and relaxation vary across occupational groups.

- The skewness of all occupational groups increased in the biophilic environment. This may indicate that the biophilic environment creates an asymmetric brain activity in certain cognitive processes, with more intense activities occurring in different brain regions.
- It was observed that the skewness value of participants with and without previous VR experience increased in the biophilic environment. This may indicate that the biophilic environment creates an asymmetric brain activity in certain cognitive processes and more intense activities occur in different brain regions. In addition, the PTP value of participants without VR experience was lower in the biophilic environment and higher in the non-biophilic environment. PTP value refers to the fluctuation level of brain waves. Therefore, it can be said that these participants were more relaxed and focused in the biophilic environment.
- Participants who had no knowledge about biophilic design had higher skewness values and lower PTP values in the biophilic environment. An increase in the skewness value indicates that brain activity is concentrated in certain regions or exhibits an asymmetric distribution. This suggests that the biophilic environment may trigger certain mental processes in these participants. However, a low PTP value indicates that brain activity was more balanced and stable, suggesting that these participants were more relaxed in the biophilic environment. In the low-information participants, complexity was found to be lower in the biophilic environment compared to the non-biophilic environment. Lower complexity indicates that brain activity is more organized and simpler, meaning that these participants also experience less mental stress in the biophilic environment. In conclusion, the biophilic environment produced positive effects such as mental relaxation and reduced stress in both no-knowledge and low-knowledge participants.

- While HE, CD and Lfuzz values increased in biophilic environment, LLE value decreased. The increase in HE, CD and Lfuzz values in the biophilic environment indicates that this environment creates more complexity, flexibility and dynamic mental processes in brain activities, while the decrease in LLE value suggests that these complex processes occur in a more organized and stable manner. The biophilic environment may have both increased mental arousal and contributed to a more balanced and controlled mental excitability in the participants.
- Women's Lfuz value increased in the biophilic environment. This increase may indicate that the biophilic environment promotes more creative thought processes or more dynamic mental activity in women. Men's CD, AppEN, Lfuzz, Perm and SpEn values increased in the biophilic environment, indicating that the biophilic environment creates a more generalized mental complexity and cognitive activity in men. This may indicate that men experience greater cognitive excitation and creativity in their mental processes in the biophilic environment.
- In the non-biophilic office, participants aged 24-34 years have a lower HE value and a higher LLE value than participants aged 53+. . The lower HE value in participants aged 24-34 years may indicate that they exhibit less complex and more organized brain activity in the non-biophilic environment. Individuals in this age group may experience more controlled and structured mental processes in non-biophilic environments. Participants in the 24-34 age group had higher LLE values, indicating that their brain activity was more chaotic and more responsive. This may indicate that younger participants experience more variable and chaotic mental processes in the non-biophilic environment and exhibit more cognitive flexibility and mental mobility. Participants over 35 may have experienced more complex but more stable mental states in the non-biophilic environment.
- Participants aged 24-34 years had lower KDF, HE, CD, LFuzz, LFuzz, Perm values and higher LLE values in the biophilic office. They may have exhibited more balanced, organized and less complex mental activities in the biophilic office environment. The lower values of KDF, HE, CD, Lfuzz and Perm

indicate that mental processes are more controlled and less stressful. A high LLE value indicates that the brain activity of this age group is flexible, meaning that their mental processes can adapt quickly to changes in a biophilic environment and have a more dynamic structure. Participants over 35 years of age have a higher Perm value in the biophilic office. This indicates that the mental processes of this age group are smoother and less ambiguous in the biophilic environment.

- While the CD, LFuzz, Perm, SpEn, value is higher in the biophilic office, the LLE value is lower. Biophilic environment provides more cognitive complexity, flexibility and creativity in academics, indicating that these processes are carried out in a more balanced and controlled manner. This indicates that academics both engage in more complex mental processes and manage these processes in a more organized manner in the biophilic environment. Participants in other occupational groups, on the other hand, had higher Perm values in the biophilic environment. This may indicate that the biophilic environment made their mental structure more dynamic and variable, perhaps triggering more free thinking or creativity processes. In contrast to academics, these participants may have exhibited a more complex but less organized mental activity in the biophilic environment.
- The CD, LFuzz, and Perm values of participants with no previous VR experience were higher in the biophilic office, while the LLE value was lower. In conclusion, participants with no previous VR experience experienced more complex and dynamic cognitive processes in the biophilic office, while these processes had a more organized and balanced structure. The biophilic environment may have provided both mental stimulation and balance in these participants. Participants who had previously experienced VR had higher CD values and lower LLE values in the biophilic environment. While participants who had previously experienced VR experienced intense cognitive complexity in the biophilic environment, they were able to manage this complexity in a more organized and balanced manner. This indicates that the biophilic environment has both a stimulating and stabilizing effect on their mental processes.

- Participants who had no knowledge about biophilic design had higher HE, CD, Lfuzz, Perm values and lower LLE values in the biophilic office environment. This shows that the participants experienced more complex and dynamic mental processes in the biophilic environment, but were able to manage these processes in a more balanced and controlled manner. The biophilic environment seems to have provided both mental stimulation and balance in these participants. Participants who had little knowledge about biophilic design had higher CD and Perm values and lower LLE values in the biophilic environment. This suggests that they too experienced increased complexity and dynamism in their mental processes, but that the processes were still maintained in a more balanced manner.

In this study, an evaluation of the integration of biophilic design elements into office spaces was made by taking expert opinions and the role of these elements on the well-being and physiological effects of the participants was examined with experimental methods. The data from the expert questionnaires and the empirical findings were combined to provide a detailed overview of the physical, mental and psychological dimensions of biophilic design. A general summary and evaluation of these findings is presented below.

Biophilic design elements that are considered appropriate to be integrated into office design according to expert opinions are; getting sunlight, using natural materials (wood, marble, etc.) that change over time, having a nature view, the use of color tones such as soil, green, blue, which reminds of nature, green-leaved (monochrome) plants, using contrasts that complement each other.) that change over time, having a nature view, the use of color tones such as soil, green, blue, which reminds of nature, green-leaved (monochrome) plants, using contrasts that complement each other (such as using light and dark colors together), presence of a design element to evoke water, multi-colored leafy plants, flowering plants, using materials such as mirrors that reflect light, using organic forms, medium sized plants, small sized plants, existence of patterns created by abstraction of animate and inanimate beings/shapes in nature, presence of objects depicting living things in nature (bird, tree, seashell), scattered - shaped plants, round-shaped plants, fine textured plants, using oval and round forms, using fractal (snowflake, leaf, cone) patterns found in nature An important result of

the study is that architects and interior architects other than landscape architects do not have sufficient awareness about the transfer of natural elements to designs. It is thought that this issue is especially important in the discipline of architecture, and it is thought that it would be beneficial to give importance to undergraduate and graduate courses on the subject and to informative studies on this subject by professional chambers.

In the experimental part of the thesis, the physical, psychometric and EEG findings of the biophilic and non-biophilic office designs designed with the findings obtained from the expert questionnaires were blended and evaluated, and the effects of these environments on mental processes and stress levels were analyzed. Since the research targets a young and academic audience, the findings have important implications especially for this group.

In non-biophilic office environments, there was a significant increase in participants' pulse levels and higher values of systolic blood pressure in male participants than in female participants. This suggests that non-biophilic environments create physical stress and that this stress coincides with high Beta and Gamma waves in EEG findings. While high Beta waves indicate mental stress, Gamma waves indicate high cognitive processing intensity. In this context, it can be concluded that physical stress transforms into mental stress and creates cognitive load in the participants.

On the contrary, it was observed that participants' pulse and blood pressure values were lower in biophilic office environments, which led to a decrease in mental stress levels. The detection of low Beta and Gamma waves in EEG data suggests that this physical relaxation is also reflected in mental processes and stress is reduced. Psychometric tests also support these results, showing that biophilic environments lead to a more balanced mental state in participants.

Psychometric findings showed that inattention errors (E2) increased in biophilic office environments, but overall test scores (CP) were lower than in non-biophilic offices. This finding suggests that biophilic environments may induce relaxation in participants, but this relaxation may result in a slight decrease in cognitive performance. The increase in Alpha waves in the EEG data supports this relaxation in biophilic environments. Alpha waves are generally associated with low stress levels,

so biophilic environments provided mental relaxation and supported attentional processes.

In non-biophilic environments, participants' overall test achievement was high, but their capacity to sustain attention declined. This suggests that non-biophilic environments negatively affect cognitive performance by increasing physical stress. The high Beta and Gamma waves in the EEG data reveal that the participants were under mental pressure and had difficulty concentrating in these environments.

In biophilic offices, EEG data show that brain waves (especially Alpha, Delta and Theta) are more balanced and at lower stress levels. These findings coincide with the fact that physical stress indicators such as heart rate and blood pressure are also lower in biophilic environments. In non-biophilic environments, on the other hand, Beta and Gamma waves increased, indicating that physical stress combined with mental stress created more pressure on the participants. The higher Alpha and Theta waves of academics in biophilic environments suggest that they experience more mental clarity and relaxation in these environments, while students experience more mental pressure in non-biophilic environments, which is also supported by EEG findings.

It was found that participants' skewness values were higher, RMS, PTP and complexity values were lower in biophilic office designs. This shows that biophilic environments make the mental processes of the participants more balanced and low energy consuming, thus reducing their stress levels and providing mental relaxation. The higher skewness value of female participants in the biophilic environment suggests that this environment creates a more pronounced asymmetric brain activity in women and mental processes are more focused. The fact that male participants' PTP and complexity values were lower in the biophilic office and mobility values were higher in the biophilic office suggests that the biophilic design provides a more balanced, organized and flexible brain activity in men. These findings suggest that biophilic environments have different but generally positive effects on the genders; women experience more intense mental processes, while men achieve more stable and organized mental states.

In terms of age groups, participants aged 24-34 years had lower energy and activity values in biophilic environments, indicating that this age group shifts to a calmer and

less active mental state in biophilic environments. On the other hand, the fact that these values were higher in participants over 35 years of age suggests that the biophilic environment creates more mental stimulation and energy consumption in this age group. In terms of occupational groups, it was observed that CD, Lfuzz, Perm and SpEn values of academicians were high and LLE values were low in biophilic environments. This shows that biophilic environments create more complex and flexible cognitive processes on academics, but these processes can be managed in a balanced way.

Participants without VR experience had higher CD, Lfuzz and Perm values in the biophilic environment, while their LLE values were lower. This finding shows that biophilic environments create complex mental processes in participants without VR experience, but these processes have a more balanced and organized structure. Participants with VR experience experienced more intense cognitive complexity in the biophilic environment, but were able to manage this complexity in a more organized manner.

The findings of this study unequivocally highlight the substantial benefits that biophilic design offers for both the physical and mental well-being of office workers. By incorporating elements of nature into the workspace, employees experience improved health outcomes and enhanced mental wellness. In non-biophilic office environments, employees' stress levels were found to increase and mental pressure was evident. In contrast, office designs with biophilic elements were found to reduce stress levels, stabilize mental processes and provide relaxation. Although some differences were observed according to gender and age groups, overall, it was found that biophilic design offers a more productive and healthier work environment by alleviating cognitive load and balancing energy consumption at work. These findings suggest that the widespread implementation of biophilic design in offices can be an effective way to improve employee well-being.

9 Discussion

In the 18th century, as a result of the Industrial Revolution, which began with the introduction of steam-powered machines, there were significant changes in both production processes and working conditions (Allen, 2011). As a result, the number of corporate companies has increased worldwide. With the proliferation of corporations, administrative activities in businesses have expanded and more administrative staff are needed to manage these activities. Accordingly, the need for office space has emerged to provide dedicated workspaces for these staff (Allen, 2011; Seitz, 2019).

Today's lifestyles have made the workplace a central element of individuals' daily routines. This has led many people to spend a large part of their time in closed office environments. In this context, the design of office spaces gains great importance. It is known that being in closed environments for long periods of time has negative effects on the health of individuals. Therefore, the critical role of office design in reducing these negative effects should be emphasized (Mendell, 1993).

Biophilic design can be defined as an approach that aims to enhance people's mental and physical health and involves the integration of natural elements and patterns into architectural designs. Today, however, this design goes beyond the mere use of vegetation in buildings and offers a more complex and richer approach that encompasses the physical, sensory, conceptual, morphological, material and spiritual dimensions of nature (Molthrop, 2011).

Research on the effects of office spaces designed with biophilic design principles has revealed that this approach makes significant contributions to business life. In particular, there have been significant increases in the performance, productivity and concentration levels of employees, as well as improvements in the positive emotional states of individuals. The combination of these benefits not only increases employee happiness and motivation at work, but also positively affects overall work performance. Thus, biophilic design is an approach that not only offers a physical aesthetic, but also has strong potential to improve workplace health, employee well-being and overall workplace productivity (Al-Dmour et al., 2021; Han & Ruan, 2019; Raanaas et al., 2011; Sanchez et al., 2018; Shoemaker et al., 1992).

In Gao et al., (2023)'S research, biophilic design criteria were discussed within the scope of the literature review and examined under three main headings: "Nature in Space", "Natural Analogs" and "Nature of Space". These three categories were renamed within the scope of the study and defined as "Direct experience of nature in the office space", "Natural analogies of office products" and "Natural experience between human and product in the office". A total of 12 biophilic design elements were addressed in the study and conducted through case study method. In the first stage, a prototype of a smart office product with biophilic elements was designed to minimize the physical and mental discomfort of office workers. Then, office users' experiences with this product were evaluated. According to the results of the study, the practical use experience of the design exceeded the user expectations and the process of integrating biophilic design into the office environment with smart products was found to be practically feasible.

A survey consisting of 120 questions was conducted to measure the effects of biophilic design on the performance of employees in 8 office buildings in Lagos, Nigeria. A total of 58 office workers participated in this study and it was found that biophilic design has a significant impact on the work productivity of employees. However, it was concluded that biophilic design strategies applied in buildings are insufficient and need to be addressed more comprehensively (Aduwo et al., 2021).

In order to examine the effect of biophilic design elements such as the presence of plants, natural light, natural landscape, air, natural pictures, materials and colors on the well-being and performance of employees, a survey study was conducted with 160 office employees. According to the results of the study, it was determined that office environments with biophilic elements positively affect both the well-being and performance of employees. In addition, these elements were also found to increase social interactions in the workplace (Alipour & Khoramian, 2023). The study, conducted in the construction industry in Egypt, investigated the level of awareness of the effects of biophilic design on human health and its application areas. In this framework, a questionnaire examining the benefits and usage experiences of biophilic design was prepared and administered to a total of 70 people, including architecture students, developers, government officials, project managers and academics from the construction discipline. According to the results of the survey, the most informed group on biophilic design was academics, while other respondents had limited

knowledge. In addition, it was determined that other groups of experts found green roof applications particularly important (Tahoun, 2019). In a survey of employees at the Genzyme headquarters in Massachusetts to assess the impact of a new building using biophilic design elements, the majority of respondents indicated that this design approach positively impacted their productivity, happiness and engagement at work. Around 72% of employees surveyed said they felt more alert and productive in the new building, while 88% emphasized that the visibility and access to the interior gardens increased their sense of well-being. In addition, 75% of employees said that the open window design strengthened their connection with their colleagues, and 92% said that the building's interaction with nature increased their sense of pride in Genzyme (Lerner & Stopka, 2016).

In this thesis, the basic elements of biophilic design are examined and these elements are adapted to office designs in line with expert opinions. In addition, it is aimed to determine the effects of the office environment designed in line with these biophilic criteria on the stress level and mental health of individuals using virtual reality (VR) with cognitive and physiological evidence. In this way, the contributions of biophilic office design to the psychological and physical well-being of employees were tried to be revealed with more concrete data.

First of all, in line with the literature reviews conducted in this study, biophilic design elements were evaluated for use in office designs. As a result of this evaluation, biophilic design elements were adapted to office designs. Biophilic design elements were integrated into office environments under two main dimensions, "Nature in Space" and "Production of Nature", as eight headings and 23 design features. In addition, the level of importance of these elements was analyzed and evaluated through expert surveys. In this way, it was determined which elements of biophilic approaches are more critical in office designs.

Biophilic office design incorporates natural light and natural views through large windows. The results of the survey showed that the participants consider the presence of daylight and natural views in office spaces to be crucial. According to Knoop et al., (2020) the proper use of natural light enhances the quality of life indoors. Natural light improves cognitive functions, positively influences mood, and supports healthy sleep patterns. Additionally, it contributes to energy savings, thereby promoting a

sustainable indoor environment. Natural light improves individuals' cognitive functions, positively affects their mood and promotes sleep patterns. It also contributes to energy savings indoors, serving a sustainable environment. Employees in offices exposed to daylight have better sleep quality and health and well-being (Lee & Boubekri, 2020). In a study, the effects of electrochromic glazing on the perceived physical and emotional well-being of office workers were evaluated. In this context, 30 office workers worked in two different office environments with electrochromic glass and partially obscured standard glass. According to the findings of the study, participants working in offices with electrochromic glass reported being more satisfied with daylight conditions and outdoor views. They also reported less eye strain and depressive feelings, suggesting that electrochromic glazing contributes positively to employee well-being (Woo et al., 2021). A study of 355 people working in 5 science parks in Scotland found a linear relationship between employees' use of green space and their ability to observe plant species such as trees and shrubs through windows indoors and their well-being. This study demonstrates the potential of green spaces in workplaces to contribute to employees' overall well-being and highlights the importance of workplace designs that incorporate restorative window views (Gilchrist et al., 2015).

The presence of indoor plants is considered by experts as an important element of biophilic office design. Indoor plants have positive effects on employees, and the use of live plants, especially in windowless office environments, increases their work efficiency and reduces their stress levels. In a comparison of two different windowless work environments, offices with and without plants, the cognitive speed of employees was analyzed. According to the findings of a study, the cognitive speed of employees working in environments with indoor plants was found to be 12% higher and their stress levels were found to be lower (Lohr et al., 1996). According to another study conducted on a company in Japan, small indoor plants were placed on the desks of 63 employees. The results showed that these small indoor plants had a positive impact on reducing psychological and physiological stress levels of employees (Toyoda et al., 2020). Experts emphasize that the presence of flowering plants as well as leafy plants is important in offices with biophilic design elements. In this direction, the study by suggests that looking at flowering plants for 3 minutes a day can have strong positive effects on human well-being. Experiments show that exposure to flowering plants

provides stress-reducing and well-being-enhancing physiological and psychological benefits. The study demonstrated the positive effects of indoor flowering plants on office workers, and these effects were also influenced by the color of the plant. In particular, it was concluded that blue flowers had the most enhancing effect on participants' feelings of relaxation compared to purple flowers and the control group.

The use of natural and patinated materials is considered by experts as an important element in biophilic design. In a study, J. Shen et al., (2020) the effects of spaces using wood and reinforced concrete elements on employees were examined. The study revealed that wood elements positively affected participants' preferences and cognitive performance. Participants reported greater attention and productivity in rooms with wood materials, as well as higher performance on neurobehavioral tests. These results support that the use of wood elements in interior design can improve both user satisfaction and cognitive performance.

Natural, organic shapes and oval forms have been recognized by experts as important elements in the design of fractal and natural patterns. It has been found that interiors designed with curvilinear forms evoke more feelings of comfort, peace and calmness than linear forms. The use of fractal patterns of medium and medium-high complexity in interiors has a positive effect on people's mood, and people find these patterns interesting (Madani Nejad, 2007). In addition, it has been emphasized by experts that the use of natural patterns in interiors increases aesthetic sensitivity and strengthens the visual appeal of the space as stated like Coburn et al., (2019)'s research.

Virtual reality (VR), one of the materials of the study, combines a high degree of control and ecological validity, providing significant advantages for both basic neuroscience research and therapeutic applications. As VR is compatible with non-invasive imaging technologies and invasive cell recording techniques, it offers a unique way to study brain activity under realistic scenarios (Bohil et al., 2011).

In this thesis, the effects of biophilic and non-biophilic office designs presented through virtual reality (VR) experience on various physiological and psychological parameters were examined. The physiological parameters measured in the study included blood pressure, body temperature, salivary cortisol level and SpO₂, and these parameters remained within normal ranges in both environments and did not show a

significant difference. In addition, the participants' performance on the D2 attention test did not differ significantly between the biophilic and non-biophilic environments. However, one of the notable findings of the study was that participants in the biophilic office environment had significantly lower pulse rates and reported lower STAI (State-Trait Anxiety Inventory) scores compared to the non-biophilic environment.

These results offer important insights into the diversity of findings observed in biophilic office design research. For example, in an experimental study with 100 healthy adult participants, offices presented in VR were categorized into two main categories of biophilic design elements: 'indoor greenery' and 'outdoor views'. One office environment contained a combination of both conditions, while the other was used as a non-biophilic control environment. After wearing the VR headset and biomonitoring sensors, participants completed stress induction tasks and then entered a six-minute recovery period in a randomly selected virtual office environment. In this experiment, biophilic environments produced greater reductions in blood pressure and anxiety levels compared to the non-biophilic environment. In particular, the indoor green and outdoor landscape conditions showed significant reductions in blood pressure and STAI scores (J. Yin et al., 2020).

As stated by Singh et al., (2010), indoor air quality, temperature, humidity, ventilation, lighting, acoustics, ergonomic design and safety also have effects on workplace stress. The reason for these differences in other studies may be due to the indoor air quality, temperature, humidity and ventilation of the experimental environment. Although no significant decrease in blood pressure was observed in this thesis, the decreases in anxiety and pulse rate in the biophilic environment are consistent with previous research. The positive effect of biophilic designed offices on anxiety levels is in line with previous studies suggesting that biophilic design can contribute psychologically to the workplace atmosphere (J. Yin et al., 2020). In this context, it can be concluded that biophilic design elements should be considered in workplace improvement strategies.

EEG data is transformed from the time domain to the frequency domain to obtain frequency-based features. In this process, important neural information is revealed by calculating the fundamental frequency components of the EEG (Murugappan & Murugappan, 2013). These frequency bands; Delta waves (0.5-4 Hz) are usually

active during deep sleep and are commonly observed in infants; they rarely occur in awake adults and adolescents. Theta waves (4-8 Hz) are slow frequency waves seen in adults during relaxation or meditation. Alpha waves (8-13 Hz) are associated with mental relaxation, memory functions and visual information processing. Beta waves (13-30 Hz) reflect states of alertness, attention and intense thinking, while their levels may increase in moments of fear or panic. Gamma waves (30 Hz and above) are associated with complex cognitive functions such as sensory perception, information processing and integration of audiovisual stimuli in the brain (Dadebayev et al., 2022). Frequency bands are used to characterize various cognitive processes, such as an individual's emotional states, mental workload, problem-solving capacity and meditation (Suhaimi et al., 2020). In this context, it is predicted that biophilic design will help to decrease the high-frequency bands associated with the state of arousal and increase the low-frequency bands associated with the state of relaxation. In the thesis study, it was found that the Beta and Gamma waves of the participants in the biophilic office environment were at lower levels compared to non-biophilic environments. For example, it was observed that the use of plants, an element of biophilic design, decreased Alpha and Beta waves, indicating that biophilic elements positively affect cognitive processes (Li et al., 2022).

This findings of thesis demonstrates that biophilic design is not confined to physical environments alone but also proves effective in stress management and neurophysiological relaxation in virtual settings. The research indicates that biophilic design positively impacts cognitive performance and mental well-being in both physical and virtual environments. The incorporation of biophilic elements provides physiological and psychological benefits in physical spaces by reducing stress levels, while similarly promoting relaxation in virtual environments, thereby enhancing mental processes.

In the biophilic environment, female participants had higher Delta, Theta, Alpha and total power values than male participants, and similar results were observed in the non-biophilic environment. Women reacted differently than men in both offices, showing less stress, especially in the biophilic office. Brain waves were higher in male participants in the non-biophilic environment, but the biophilic environment provided a more balanced brain activity by reducing stress in men.

The finding that women are more positively affected by well-designed spaces, especially biophilic offices, than men emphasizes the importance of the gendered effects of biophilic design. This finding suggests that women's cognitive and emotional well-being is more supported in environments enriched with elements of nature. The results of the working memory test also revealed that there were significant improvements in the relationships between different frequency bands in women's brains in biophilic environments (Rhee et al., 2024). These results are consistent with the results of the thesis study.

Demographic and experiential factors such as participants' age, occupation, postgraduate education, VR experience, and whether or not they had biophilic design had a significant impact on the changes in EEG waves between different environments. Participants over the age of 35, academics, those with VR experience and those with no knowledge of biophilic design were the most positively affected by the biophilic environment. These findings are confirmed by studies on the effect of education, gender, socioeconomic status on EEG waves (Díaz De León et al., 1988; Ramanand et al., 2010; Sherrill-Pattison et al., 2000).

In the biophilic environment, RMS, PTP, Complexity, LLE values decreased, while Skenewnes, HE, Lfuzz values increased. At high stress levels or intense mental processes, the irregularity in EEG signals increases. In this case, the peaks of the signal in both positive and negative directions are sharper and have larger amplitudes than in normal cases. Therefore, the properties calculated in the time domain are expected to increase in such signals (Fasil & Rajesh, 2019). These findings suggest that the biophilic environment may be associated with increased brain activity, i.e. increased attention and decreased stress. As with the spectral EEG waves, there were differences in the level of influence of the environments depending on the demographic characteristics of the participants. These data in the study are in same line with the spectral data.

10 Conclusion

In the modern world, people spend most of their time indoors and the design of these spaces is extremely important, especially for office workers. Biophilic design is an architectural approach that aims to strengthen the connection between humans and nature through the use of natural elements in built environments. Office design has a significant impact on the health and performance of employees, improving their quality of life and increasing the productivity of businesses. This study aims to identify biophilic elements in office designs that enhance employee health and performance, and to contribute at both individual and organizational levels through the implementation of these elements. Although there are studies in the literature that examine office designs and biophilic design elements, there are very limited studies that examine all biophilic elements in the context of office designs with experimental methods and comprehensively address the effects of these elements on people.

This study supports the main hypothesis that biophilic design positively affects individuals' physiological and psychological responses, reducing their stress levels and improving their cognitive performance. The results of the study revealed that office environments enriched with biophilic elements significantly improved employees' cognitive processes such as attention span and cognitive flexibility, while reducing stress. In addition, demographic factors such as age and gender were found to play an important role in the responses to biophilic design. The study revealed that biophilic design elements such as natural light, vegetation, water elements, natural materials and organic forms are critical in office environments and emphasized the positive effects of these elements on the physical and mental health of employees. Physiological stress indicators were found to be higher in individuals working in non-biophilic offices compared to biophilic offices, and EEG and psychometric tests proved that biophilic design contributes to mental processes by increasing attention span and improving cognitive performance. In this context, it is concluded that the effects of biophilic design on individuals vary depending on demographic characteristics, but in general, it contributes positively to the health and performance of employees.

This study examined the physiological (e.g. EEG data) and psychological effects of biophilic design and detailed its relationship with demographic variables, filling an

important gap in the literature. The research extends the theoretical foundations in this field by addressing the effects of biophilic design on stress levels and cognitive performance through experimental methods. It also developed practical applications by adapting biophilic design elements to office designs in line with expert opinions. In this respect, it deepens the existing theories on human-nature interaction and provides concrete strategies that can be used in office designs.

The research examined the effects of biophilic design elements on physiological and psychological mechanisms by combining the perspectives of environmental psychology and neuroscience. This approach adds a new dimension to the biophilia hypothesis. In particular, the effects of biophilic elements on enhancing cognitive performance and reducing stress were supported by empirical findings, contributing to the deepening of existing theories on human-nature interaction.

The study also presents an innovative approach using virtual reality (VR) technology to experience and analyze biophilic design elements. VR technology allowed participants to experience simulated office environments enriched with biophilic design and without biophilic elements. This method allowed for a detailed examination of the effects of environmental variables and offered an innovative perspective to avoid the high costs of creating real environments.

In addition, the study provides a practical guide for the integration of biophilic elements in office design. The use of natural light, plants, water elements and natural materials supports sustainability principles while improving employee health and productivity. These findings suggest that VR technology can be used as a cost-effective solution in architecture and design processes.

Despite the methodological strengths of the study, some difficulties were encountered. In particular, there were problems in the questionnaire administration process and the long turnaround time of the expert questionnaires caused serious time loss in the data collection phase. This led to disruptions in the evaluation of the feedback received from experts and the finalization of the results. It is considered that such problems can be prevented by cooperating with professional chambers.

Another challenge encountered during the experimentation phase was that it was not always possible to keep environmental factors (e.g. humidity, temperature and air

quality) constant. The inability to control these factors was seen as a potential limitation that could affect the validity of the findings. Furthermore, the study's focus on a young and academic participant population created limitations in generalizing the results to the general population.

Future research needs to evaluate the effects of biophilic design in different work environments and in a broader context. An expanded study group, including individuals of different ages, cultures and occupations, would help us understand how elements of biophilic design differ according to demographic variables. Long-term data collection would allow us to more clearly demonstrate the long-term effects of biophilic design, which would help us understand how the effects on factors such as stress management, creativity and job satisfaction change over time.

Investigating how the perception of space appeals to the five senses and taking into account environmental factors, such as air quality, humidity and temperature, will increase the accuracy of the research. This allows for a detailed analysis of biophilic design elements, but also allows us to observe the effects of space on sensory experiences. In this context, the different types of spaces - indoor, semi-open and open spaces - and their sensory effects on human beings are important for a comprehensive evaluation of biophilic design.

Applications in specialized healthcare institutions such as hospitals are of great importance to investigate the healing power of spaces, especially for patients with psychological disorders, to demonstrate the potential health benefits of biophilic design. Biophilic interventions in such environments can support both the physical and psychological healing processes of patients.

Exploring the differences in biophilic design practices between public and private spaces allows us to better understand the use of these different types of spaces and their impact on human behavior. Observing how the integration of biophilic design elements in public spaces can improve their functionality and user experience contributes to the development of strategic recommendations for designers and policy makers.

Finally, the economic and social impacts of biophilic design need to be comprehensively addressed. By conducting a cost-benefit analysis, the long-term

benefits of this approach for businesses and employees can be more clearly demonstrated. Such studies will support the applicability of biophilic design at both local and global levels and will provide an important basis for the development of sustainable and human-centered design approaches.

This study has made significant contributions to the literature both locally and globally by revealing the effects of biophilic design on human health and cognitive performance with scientific data. In the local context, it has shed light on the development of applications in this field by providing solutions specific to work environments in Turkey; on a global scale, it has guided sustainable and human-centered design approaches by supporting the universal validity and benefits of biophilic design with empirical data. The study has not only increased employee health and productivity, but also provided a strategic perspective on the social, economic and environmental sustainability dimensions of design, providing a multifaceted perspective in the scientific field.

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Appendixes

Expert survey

Age	Gender	Profession	1) Female	2) Male
In addition to your specialization, have you received postgraduate education related to your field?				
			(1) Yes	(2) No
If yes, at which level did you receive graduate education?				
			(1) Master's Degree	(2) Doctorate
I know about biophilic design			(1) Yes	(2) Partially
I agree to participate in the research			(1) Yes	(2) No
Read the statements for office designs below and evaluate them from 1 to 5 according to their importance and make the necessary marking in the box on the side.				
1- Not at all important, 2- Not important, 3- Doesn't matter 4- Somewhat important, 5- Very important				
Nature in space	Visual connection with nature	Landscape		
		Fire	Having a view of nature	
		Plant presence	Finding an element that I can connect with fire / evokes fire	
			Pyramid-shaped plants	
			Column-shaped plants	
			Round-shaped plants	
			Scattered -shaped plants	
			Rough textured plants	
			Medium textured plants	
			Fine textured plants	
			Large-sized plants	
			Medium-sized plants	
			Small-sized plants	
			Green-leaved (monochrome) plants	
			Multi-colored leafy plants	
			Flowering plants	
			Pet presence	
		Animal presence		
		Water	Presence of a design element to evoke water	
	Non-visual connection with nature	Aging, Change, natural materials bearing the traces of time	Using natural materials (wood, marble, etc.) that change over time	
		Use of natural colors	The use of color tones such as soil, green, blue, which reminds of nature	
	Dynamic and diffuse light	Diffuse light	Using materials such as mirrors that reflect light	
		Daylight	Getting sunlight	
		Seashells and Spirals	Using spiral forms	
		Oval and Round Shapes	Using oval and round forms	
		Straight and non-right-angled forms	Using organic forms	
		Simulation (abstraction) of Natural Properties	Existence of patterns created by abstraction of animate and inanimate beings/shapes in nature	
		Using fractal geometry	Using fractal (snowflake, leaf, cone) patterns found in nature	
		Complementary Opposites	Using contrasts that complement each other (such as using light and dark colors together)	
		Objects that reminding nature	Natural landscape painting presence	
			Presence of pictures of living things in nature	
			Presence of objects depicting living things in nature (bird, tree, seashell)	
Production of nature (Production of Nature)	Biomorphic forms and patterns			

Appendix B

Participant questionnaire

PARTICIPANT NO: NAME FULL NAME:					
1	Age				
2	Gender	Female		Male	
3	Education status	High School	License	Master's degree	PhD
4	Profession				
5	Have you experienced VR before?	No		Yes	
6	Do you know about biophilic design?	I don't have knowledge	I have little knowledge	I am very knowledgeable	

Appendix C

D2 Test of Attention

	TN	E1	E2	CP
1	d d p d d	" d p p d	" d d p d	" d d p d d p
2	p d d p d	" d d p d	" d d p d	" d d p d d
3	d d d p d	" d d p d	" d d p d	" d d p d d
4	d d d p d	" d d p d	" d d p d	" d d p d d
5	p d d p d	" d d p d	" d d p d	" d d p d d
6	d d d p d	" d d p d	" d d p d	" d d p d d
7	d d d p d	" d d p d	" d d p d	" d d p d d
8	p d d p d	" d d p d	" d d p d	" d d p d d
9	d d d p d	" d d p d	" d d p d	" d d p d d
10	d d d p d	" d d p d	" d d p d	" d d p d d
11	p d d p d	" d d p d	" d d p d	" d d p d d
12	d d d p d	" d d p d	" d d p d	" d d p d d
13	d d d p d	" d d p d	" d d p d	" d d p d d
14	p d d p d	" d d p d	" d d p d	" d d p d d

Appendix D

STAI form

Self-evaluation questionnaire of the “State-Trait Anxiety Inventory – State” (STAI-S)

Name: _____ Date: _____ Year: _____

INSTRUCTIONS: Some statements that people have used to describe their feelings are given below. Read each statement and then circle the response option to the right to indicate how you feel right now, that is, at this moment. Do not spend too much time on any one statement, but give the answer which seems to describe your present feelings best.

Not at all ----- 1
Somewhat ----- 2
Moderately ----- 3
Very much ----- 4

- | | | | | |
|---|---|---|---|---|
| 1. I feel calm..... | 1 | 2 | 3 | 4 |
| 2. I feel secure..... | 1 | 2 | 3 | 4 |
| 3. I am tense..... | 1 | 2 | 3 | 4 |
| 4. I am regretful..... | 1 | 2 | 3 | 4 |
| 5. I feel at ease..... | 1 | 2 | 3 | 4 |
| 6. I feel upset..... | 1 | 2 | 3 | 4 |
| 7. I am currently worried about possible misfortunes..... | 1 | 2 | 3 | 4 |
| 8. I feel rested..... | 1 | 2 | 3 | 4 |
| 9. I feel anxious..... | 1 | 2 | 3 | 4 |
| 10. I feel comfortable..... | 1 | 2 | 3 | 4 |
| 11. I feel self-confident..... | 1 | 2 | 3 | 4 |
| 12. I feel nervous..... | 1 | 2 | 3 | 4 |
| 13. I am jittery..... | 1 | 2 | 3 | 4 |
| 14. I feel “high-strung” | 1 | 2 | 3 | 4 |
| 15. I am relaxed..... | 1 | 2 | 3 | 4 |
| 16. I feel content..... | 1 | 2 | 3 | 4 |
| 17. I am worried..... | 1 | 2 | 3 | 4 |
| 18. I feel overexcited and rattled..... | 1 | 2 | 3 | 4 |
| 19. I feel joyful..... | 1 | 2 | 3 | 4 |
| 20. I feel fine..... | 1 | 2 | 3 | 4 |
-

Appendix E

Participants inclusion criterias

Participant no		
INCLUSION CRITERIA	Yes	No.
I do not have any hormonal disease		
I have no psychiatric illness. I do not use any medication for therapeutic purposes		
I don't have a sleep disorder		
I don't have a sleep disorder		
I do not have heart disease. I do not use any medication for therapeutic purposes		
I do not suffer from hypertension/hypotension. I do not take any medication for treatment		
My body mass index is normal ($18.5 < \text{Body Mass Index (kg/m}^2) < 25.0$)		
I did not consume caffeine on the day of the experiment		
I slept 7-9 hours before the day of the experiment		
<u>I VOLUNTARILY agree to participate in the research</u>		
<u>Signature</u>		