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DETERMINING THE COGNITIVE PERCEPTION OF DIFFERENT SETTLEMENT CHARACTERISTICS OF PEOPLE IN THE URBAN AREA

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Abstract: This study was conducted with the aim of obtaining directly from the user the factors that should be considered in the design, structuring, and rehabilitation processes of the physical environment. Real spatial environment was selected as the experimental environment. To obtain the necessary data, the Beck depression test was performed before the experiment, and the relevant measuring devices were adapted to the subjects for EEG-HRV measurements during the experiment. The main purpose is to physiologically measure how people are affected by different environments in the city; To determine the effects of the city on people and to reveal the cognitive effects of different environments. Users themselves were directly involved as subjects in the study. Results will contribute to the management of the user-oriented design process in making the urban physical environment more qualified. The study, unlike other approaches, aimed to measure two different environmental effects physiologically and to offer suggestions about how it can affect in practice.

Keywords: Built environment; Environmental psychology; neuro-cognitive architecture

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INTRODUCTION

With the increase in population in the world, the number of people living in urban environments is also increasing rapidly. Therefore, living spaces in cities have gained importance. Urbanization is a process that causes significant changes in many areas such as people's lifestyles, livelihoods, dietary habits and exposure to environmental factors, as well as the physical changes experienced by increasing population rates in urban environments (Phillips, 1993). Increasing urbanization trend not only threatens biological diversity (Pauchard *et al*., 2006; Bradley and Altizer, 2007; Yang *et al*., 2022), but also leads to the emergence and increase of various physiological health problems such as obesity (Popkin, 1999; Voss *et al*., 2013; Eckert and Kohler, 2014; Pirgon and Aslan, 2015), diabetes (Azimi-Nezhad at al., 2008; Jørgensen *et al*., 2011; Al-Moosa *et al*., 2006), high blood pressure (Ekezie *et al*., 2011; Ibrahim and Damasceno, 2012), and psychological health problems such as depression (Bhugra and Mastrogianni, 2004; Wang *et al*., 2018; Sampson *et al*., 2020).

Today, the majority of the world's population lives in urban areas, and this number is increasing day by day. Therefore, research on the human well-being of urban areas is increasing (Van Kamp *et al*., 2003; Panagopoulos *et al*., 2016; Vujcic *et al*., 2017; Krefis *et al*., 2018). The factors that determine the effects of urban environments on human well-being are quite diverse. It is important to understand the impact of these factors because they must be considered in the process in terms of urban planning and management:

- Environmental factors (existence of green areas, protection of the natural environment, air quality, water resources, lighting, and natural disasters)
- Social factors (interaction of people with each other, social support network, a fair social structure, social inequality, gender, age, and ethnicity)
- Economic factors (income level, job opportunities, inequality, poverty, and urban poverty)
- Cultural factors (social norms, cultural diversity, language, and religious differences)
- Architectural factors (green areas, social areas, natural light, sustainability, and accessibility).

With the increase in urbanization, natural areas are decreasing, and this situation brings many problems.The physical components with very different characteristics that the settlements have accumulated in the historical process. The most important of these, green areas are indispensable for people in cities to lead a healthy life. Green areas allow people to preserve their natural environment and experience natural life. Urban green areas increase property value due to their pleasant and esthetic characteristics to maintain environmental sustainability, improve the quality of life and air quality, reduce the energy costs of cooling buildings, and provide ecosystem services such as recreation and recreational facilities (Haq, 2011). Therefore, green areas play an important role in social, economic, cultural, and environmental aspects in terms of sustainable development (Haq, 2011). These areas improve air quality in cities (Selmi *et al*., 2016). These areas also help cities become more sustainable by preventing temperature rises in the city (Zhang *et al*., 2014). Green areas help manage the water cycle in cities and reduce water pollution (Mexia *et al*., 2018; Liu *et al*., 2023). Urban green areas play an important role in maintaining a natural balance in city life and help people connect with natural environments. Therefore, the design of green areas in cities is one of the most important strategies used by architects and urban planners to promote constant contact with nature and contribute to people's physical and mental health. (Haq, 2011; Zhang *et al*., 2015; Erkan, 2023).

The impact and benefits of different urban environments on people's well-being have been investigated in recent years (Pretty, 2004; Moore *et al*., 2006; Sugiyama *et al*., 2008; Kamitsis and Francis, 2013; Chu *et al*., 2021; Liu *et al*., 2021; Sadeghi *et al*., 2022; Tae *et al*., 2022; Zhang *et al*., 2022; Huang *et al*., 2023).

In a similar study by Erkan (2023), urban green environments, which are one of the important factors in urban design, increase attention, reduce stress and anxiety, improve the physical and mental health of residents by improving mood and well-being, and contribute to discussions on how to plan for healthy cities (Erkan, 2023). The aim of this study is to measure the cognitive responses to historical and modern buildings, with the acceptance of the findings related to the green area as a result of the study being carried out in a real natural environment and the data obtained from physiological measurements. However, since the experimental environment of the current study is predicted to be in a qualified urban area in the future projection, a green area, which is the most important component of the urban environment, was preferred.

The reason for the study of historical and modern buildings is that the effects of urban environments with different combinations on the well-being of people have not been emphasized much. In this study, an experiment was conducted in a real environment to see how different urban textures affect people's mental well-being. This experiment will evaluate the health benefits of exposure to different urban environments in green space and will focus on the similarities and differences between psychometric and physiological measures.

Literature Review

To interact between people and the urban, the environmental conditions in which people live must be suitable. Therefore, all factors that affect human health and well-being, such as social, political, and environmental health, need to be considered (Pacione, 2003). The relationship between the changing urban environment, because of rapid urbanization and human health and well-being is of increasing significance. The health problems associated with the urban environment can be listed as follows (Bai *et al*., 2012):

- Infectious diseases that occur as a result of people coming together in low standard living conditions,
- Acute and chronic diseases (such as respiratory diseases and lung cancer) caused by industrial pollution,
- Chronic and non-communicable diseases are increased by unhealthy urban lifestyles such as physical inactivity, unhealthy diet, harmful use of tobacco and alcohol,
- Injuries from motor vehicle collisions, violence, and crime,
- Various health risks arising from climate change.

Along with the urbanization process, the destruction of natural areas and the increase in construction bring along various environmental problems. In this context, green areas help reduce these problems by providing a natural buffer zone. In addition, the presence of green areas contributes to reducing stress (Grahn and Stigsdotter, 2003; Van den Berg *et al*., 2010; Thompson *et al*., 2012; Roe *et al*., 2013; Beyer *et al*., 2014; Aspinall *et al*., 2015; Kondo *et al*., 2018), increasing physical and mental health(Groenewegen *et al*.,2006; Maas *et al*., 2006; Bowler at al., 2010; Richardson *et al*., 2013; Haluza *et al*., 2014; Hartig et al., 2014; James *et al*., 2016), social interaction and improving the quality of urban life. Moreover, having a mental disorder affects not only the individual but also various areas such as family, workplace, health systems, government, communities, and economic systems (Jenkins *et al*., 2011; Othman *et al*., 2020). Due to these reasons, with the urbanization process, the protection and increase of green areas are of increasing importance.

Green areas, which contribute to the environment by providing a natural environment and helping people connect with natural environments, are open areas covered with vegetation or plants such as trees, bushes, grass, and flowers. Green areas, defined as open areas covered with vegetation, can be found in urban and rural areas. (Cilliers, 2015). Urban green areas include public and private green areas. (McConnachie and Shackleton, 2010; Cilliers, 2015). Urban green areas are open areas designed as part of natural environments in cities and often used for purposes such as parks, gardens, playgrounds or sports fields. Adequately sized residential parcels provide the opportunity for users to establish and maintain productive or aesthetic gardens and create private green areas, while in areas where residential parcels are inadequate or multistory buildings are dominant, public green areas can be considered a key approach (McConnachie and Shackleton, 2010).

Historical urban environments are handled with a holistic approach that includes various dimensions such as economic, social, cultural and environmental sustainability (Landorf, 2011). These areas can help people feel close to their cultural identity and connect to historical, esthetic, and architectural values. Historical city environments also have a very important place in terms of tourism. Historical city environments are important for tourism not only economically but also culturally, historically, and socially (Kuzulugil *et al*., 2023). While these environments encourage a healthy lifestyle by allowing people to perform physical activities in terms of physical health, they provide suitable spaces for people to interact with each other in the social dimension. Finally, these areas can help people reduce their stress and relax spiritually (Reece *et al*., 2022).

After the literature review, it was concluded that exposure to green and historical environments provides significant benefits in terms of human well-being. However, to fully understand these benefits, it is necessary to use both psychological and physiological measurements together, and there has not been enough research in this direction. In addition, studies on historical environments are very few compared to green areas. This study aims to improve the existing literature by using both psychological and physiological measures to examine the effect of exposure on human well-being in the real environment, with a particular focus on combinations of modern and historical urban environments. This study will make an important contribution to future studies by obtaining a more comprehensive data set by using both measurement types together. In this direction, the possible effects on human well-being will be investigated by examining the relationship between exposure to green and historical urban environments and levels of stress, anxiety, and depression. For this purpose, psychological and physiological measurements such as electroencephalogram (EEG) and heart rate will be used in the study.

Psychophysiological responses accompany emotional responses triggered by visual perception of environmental stimuli (Berlyne, 1974). As an objective method, brain activity measurement is used to evaluate the physiological effects that occur during interaction with the environment (Schäfer *et al*., 2015). Many studies have confirmed the usability of the Emotiv headgear, which is used in health and well-being research, in outdoor environments as well as laboratory environments (Debener *et al*., 2012; Badcock et al., 2013; Milosevic *et al*., 2013; Choo and May, 2014; Aspinall *et al*., 2015; Menshawy *et al*., 2015; Neale *et al*., 2017).

Based on the perception and recording of electrical signals in the brain, EEG is an effective tool to measure the mental and physical relaxation that people feel in urban green areas. The EEG used in urban green space studies shows that it is a useful tool to measure people's interactions and experiences with green areas, used together with visual stimuli (Velarde *et al*., 2007; Olszewska-Guizzo *et al*., 2020; Davros *et al*., 2022) such as real photos and videos or during walks in green areas (Qin *et al*., 2013; Lin *et al*., 2020; Neale *et al*., 2020). While the use of EEG in the real environment is a natural way to measure the effect of urban green areas in real world conditions, the use of EEG in the laboratory environment is a method where environmental factors can be kept under control and therefore the measurements are more precise and repeatable (Wu *et al*., 2022). Environmental factors (for example, wind, noise, natural light) can affect the measurement results in EEG measurements made in real-world conditions (Khushaba *et al*., 2012). However, EEG measurements in the laboratory environment can provide a more limited perspective compared to real-world conditions. There are certain advantages and disadvantages to both methods, and therefore, the use of each should be carefully evaluated. In laboratory experiments, it can be difficult to investigate multiple parameters simultaneously (Alvarez *et al*., 2006), and laboratory data may not accurately reflect an individual's real-world experience (Neale *et al*., 2020). For these reasons, the experiment was conducted in a real environment in this study. EEG studies usually involve fewer participants because of the amount of data. For example, in the study of Lee *et al*. (2021), there are more than 7000 data points per participant, and therefore, it is considered normal to keep the number of participants low in studies conducted and limited to 40 people.

AIMS

Research has identified the benefits of exposure to green areas using qualitative methods and psychometric measurements, but it is unclear what effect it has in urban environments with different combinations. This study aims to advance the existing literature by focusing on both psychological and physiological measures to investigate the impact of real environments on human well-being, particularly modern and historical textures (environments). The study evaluated the effect on mental health of exposure to an urban environment with designed walkways, green density, and diverse urban textures, all protected from motor traffic, and combined psychometric and physiological measurements and the following hypotheses were put forward:

- RQ1: Does exposure to modern and historical urban textures and their combination and urban environments benefit mental well-being?
- RQ2: Do psychometric and physiological measures agree when assessing the health benefits of exposure to different urban environments?

METHODS

Participants

The experiment was conducted with 40 healthy adults. Twenty females and twenty males took part in the experiment, as attention was paid to the gender equality of the participants. To provide integrity in the demographic structure of the experiment, university graduates or students were selected for the experiment according to their educational status. 20 of the 40 participants were university students and the others were university graduates. Statistics regarding the educational background and age of the participants are shown in **Table 1**.

Since it was an experiment that required walking and seeing to feel emotional changes, the exclusion criteria for participation in the study included the use of alcohol, drugs, and stimulants within 24 h. Ethical approval for the study was provided by the University Ethics Committee. Human research ethics committee forms were signed by all participants before the experiment, and the whole process was explained.

Measure Procedure

The experiment was held between May 12, 2023, and May 12, 2023. The timing was chosen according to day light and sun light; therefore, it was between 10 am and

Table 1. Statistics on the educational background and age of the participants.

		Female	Male	Total
Age	Number	20	20	40
	Average Age	29.35	29.5	29.43
	Youngest Participant	21	21	21
	Oldest Participant	55	67	61
	StandartDeviation	8.33	12.05	10.22
Education background	Student	8	12	20
	Bechelor's Degree	3	3	6
	Master's Degree	7	2	9
	PhD Degree	1	0	1
	Associate's Degree	1	3	4

Fig. 1 The route of the experiment

5 pm. The average temperature was +20 Celsius and majority of the weather conditions were stable as partly cloudy. Participants walked the route shown on **Fig. 1**.

A river on the right side of the route and many buildings on the left side. The experiment started with the “Beck depression test” to analyze the psychological conditions of the participants. After the depression test process, the participants were asked to walk along the route with EEG and HRV measuring devices. As they walked, they recorded with a camera behind them to determine what they were feeling. The walking distance of the experiment was around 4–5 min, depending on the speed of the participants. After the walking process, finally, 4 questions were finally asked the participants. The experiment was analyzed according to the HRV, EEG results and additionally the test results (**Fig. 2**).

Subjective Measurements

Mood was measured with the Beck Depression Test, developed by Beck *et al*. (1961). The Beck Depression Scale is a Likert-type scale consisting of 21 questions and a scoring system between 0 and 3. The high scores obtained on the scale determine the severity of depression experienced by individuals. Each question is scored in the range of 0–3 points, and results ranging from 0 to 63 are obtained. The results are evaluated as minimal depression at the level of 0–9, mild depression at the level of 10–18, moderate depression at the level of 19–29, and severe depression at the level of 30-63 (Farinde, 2013). The sum of the scores reflects how severe the individual is in terms of symptoms of depression. The Turkish version of the test was used for evaluation, and the test was administered to the participants before the experiment.

Aparatus

Two different physiological measurement methods were used for the experiment. The first was EEG and the other was HRV, which measures heart rate.

EEG

Electroencephalography (EEG), as a medical imaging method, measures brain activity by reading electrical activities on the scalp (Teplan, 2002). There are five EEG waves Alpha, Beta, Gamma, Delta, and Theta. Some properties of these waves are shown in **Table 2**.

Table 2. EEG waves and their properties

EEG Waves	Frequency	Relationship	Increase or decrease states
Alpha	8-13 Hz	With eyes closed or a relaxing activity	It increases during relaxation, meditation, and mental relaxation states, while decreases during tasks requiring intense mental activity or attention
Beta	13-30 Hz	Focus, mental activity, attention, problem solving and conscious thinking	Increases in tasks that require intense mental or physical effort
Gamma	25-40 Hz	Creativity, cognitive processes, consciousness, memory and attention	It increases during tasks that require intense mental activity, creativity, and attention, while decreases during relaxation and leisure states
Delta	1-3 Hz	Rest, restoration, the body's healing process and immune system functions	It increases during deep sleep and relaxation states, while decreases during wakefulness and active states
Theta	4-7 Hz	Creativity, imagination, memory, deep relaxation and meditative states	Increases in conditions such as some attention deficit disorders and hyperactivity

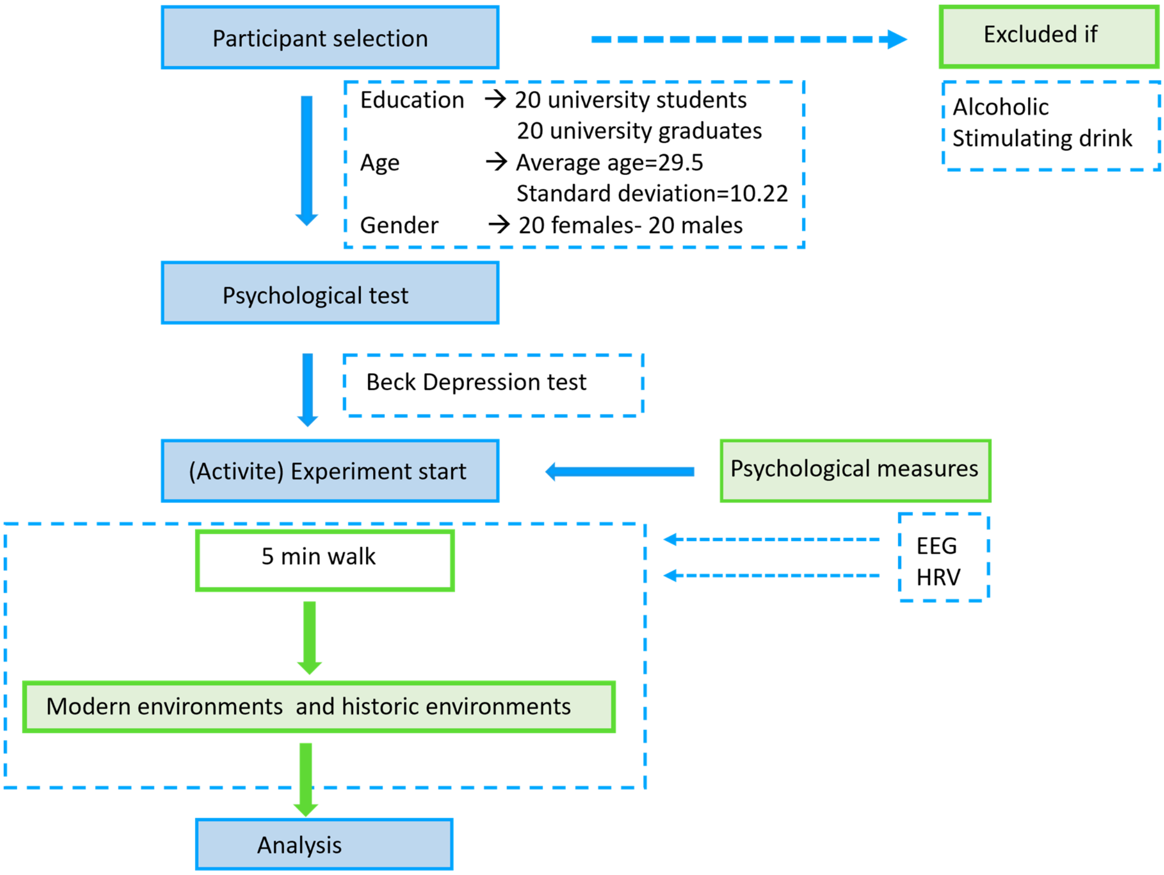

Fig. 2 Experiment flow chart.

HRV

Heart rate variability (HRV) is the variability of heart rate over time. HRV is based on the time differences between successive heartbeats. These differences reflect the regulation of the autonomic nervous system, which is associated with nervous system and heart health. Therefore, HRV is used to evaluate the functioning of the autonomic nervous system and heart health.

HRV is a measurement that provides information about heart health, stress levels, and autonomic nervous system functioning by measuring the degree of irregularity and variability of heart rate. High HRV is associated with greater variability and generally better cardiovascular health, better stress management, and overall health, while low HRV may be associated with stress, autonomic nervous system imbalances, and cardiovascular problems. In addition, HRV may reflect physiological and psychological states such as stress, depression, anxiety, and sleep disorders and may be affected by autonomic nervous system disorders.

EXPERIMENT AREA

The Çayboyu walking area in Isparta province, IN Turkey was chosen as the experimental area. The combination of green space, historical buildings (traditional), and modern buildings has been the reason for choosing this

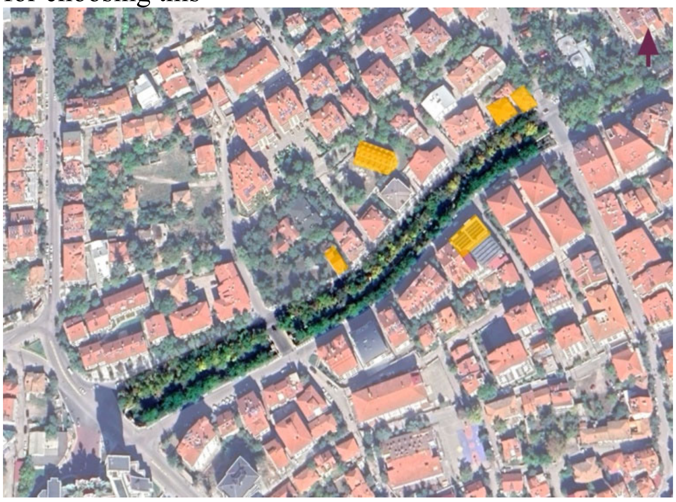

Fig. 3 Green path and Traditional Buildings on the route (Yellow Marked Buildings are the traditional buildings and rest of them are the modern building)

place. The route shown in **Fig. 3** shows that it is covered with green trees and other vegetation. For the buildings that are yellow marked, they are traditional and historically important buildings on the route.

Along a river, the axis where there is a single-lane traffic flow on both sides of the river is called "Çayboyu," and people use this route for jogging or walking as well as being a vehicle. The experimental route is 320 meters long, and the distance of the axis on which the subjects walk from the buildings is around 10 meters. Participants walked 160 meters of this route, seeing contemporary buildings in their direction of view. Then they saw a traditional residence and continued 80 meters further with modern buildings. After that, they came across a historical church building on the left side of the route, which is not at the same distance from other buildings but has a high perception due to its high clearance and large scale. As they continued to walk another 80 meters in the modern building environment, they saw another traditional residential building at the end of the road (**Fig. 4**).

RESULTS

Psychological test results

A statistically significant difference was found between the group that walked regularly and the group that did not, according to the Beck Depression Scale mean scores of the participants included in the study ($p>0.05$, **Table 3**). The variation of Beck Depression Scale Scores in participants with two different walking behaviors is shown in **Fig. 5**. **Figure 5** clearly shows that the depression level of people who walk regularly was found to be lower than the others.

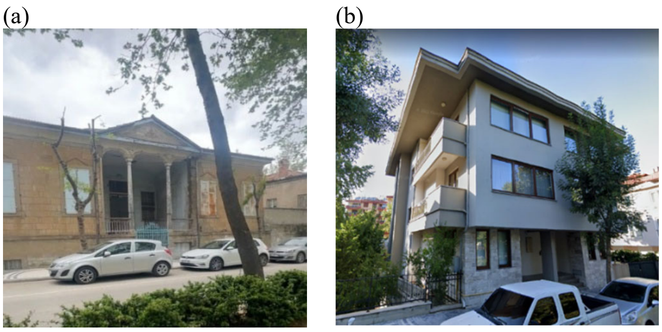

Fig. 4 Traditional building (a) and Modern Building (b) examples on the route.

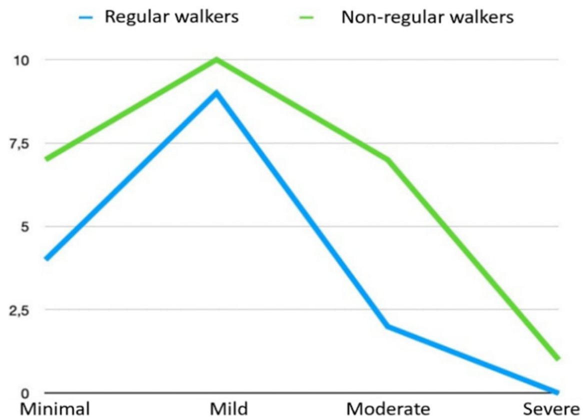

Fig. 5 Variation of participants' Beck Depression Scale scores according to regular walking and not walking

HRV Results

It demonstrates the results of comparing modern and traditional measurements of blood pressure under different conditions. The results show a significantly lower (4.3 mmHg) systolic blood pressure (SBP) after walking in the modern environment than after walking in the traditional environment ($P<0.05$). Some HRV measurements were rejected due to more than 10% artifacts and ectopic beats, reducing the number of valid HRV measurements to 36 before walking in the environment. **Table 4** is based on the average value of collected and HRV data for modern and traditional environment. It was decided to use this method because there was no statistical difference between HRV measurements in the two environments. When comparing HRV in the modern setting with HRV in the traditional setting, no statistically significant difference was found among any of the HRV variables (**Table 4**). Physiological measurements of both blood pressure (BP) and heart rate variability (HRV) did not show any significant difference between the two environments when the two perceived different environments were considered (especially HRV results).

Table 3. Beck Depression Scale score statistics.

Group	Regular walkers	%	Non-regular walkers	%	Total	Test Value	Test Value
Minimal	4	10	7	17.5	21	8.973	0.004
Mild	9	22.5	10	25	41.5		
Moderate	2	5	7	17.5	14		
Severe	0	0	1	25	1		

Table 4. Average of HRV estimates in both environments

HRV	Modern	Traditional
ln(TP)	8.71 (0.12)	7.64 (0.12)*
ln(LFP)	5.11 (0.13)	5.12 (0.12)
ln(HFP)	7.15 (0.14)***	7.41 (0.14)***
ln(LF/HF)	−0.03 (0.12)***	−0.12 (0.09)***

***P≤0.001; ** P≤0.01; * P≤0.05.

EEG Results

EEG data were analyzed with Fast Fourier Transform (FFT) MATLAB software based on studies in the literature (Murugappan & Murugappan, 2013; Murugappan *et al.*, 2014). The Fourier transforms applied to the system to filter signals from the time domain to the frequency domain are expressed mathematically as they appear in the equation:

$$s(f) = \int_{-\infty}^{\infty} s(t)e^{-j2\pi ft}\,dt \quad (1)$$

Here, s(f) = frequency domain signal, s(t) = time domain signal, $e\ -j2\pi ft$ = Constant, f = frequency, and t = time.

As a result, EEG data from 40 participants was selected as a sample for analysis. Only artifact-free EEG data were used to ensure the reliability of the analysis results. Repeated measurements and multivariate analysis of variance (MANOVA) were performed to determine whether EEG data were affected by differences between two different environments (traditional and modern). In the study, architecturally modern and traditional buildings (two opposite environments) were determined as independent variables, and a linear combination of EEG data from 14 different channels was made. After determining the effects of two different environmental factors on EEG power with MANOVA, an analysis of variance (ANOVA) was performed to analyze the effects of the environment on EEG power in each frequency band. In addition, the EEG powers of each frequency band were determined as the dependent variable, and the statistics in question were examined separately in each frequency band. There is a statistically significant interaction between traditional and modern environments and brainwave band power. It has been observed that differences in environments (modern and historical) significantly affect brain wave power. The analysis results showing whether two different environmental factors have a statistically significant effect on brain wave band power are shown in **Table 5**.

Table 5. Six main effects of walking in the environment of modern buildings and the electroencephalography power of the environment in each frequency band measured in the environment of traditional buildings

Band Power	Sum-of-squares	Degrees of freedom	Mean squares	P	F	ηρ2
Alpha	0.0043	1	0.0043	0.9878	0.4489	0.0087
Beta	0.4561	1	0.4561	0.0218	9.7854	0.2987
Delta	0.0250	1	0.0250	0.354	1.4875	0.0779
Gamma	0.9890	1	0.9890	0.0403	6.8749	0.4089
Theta	0.0240	1	0.0240	0.2589	1.8879	0.2588

* $p < 0.05$

EEG data showed that the main effects of two different environments on beta and gamma wave power were statistically significant. Figure 6 shows the power distribution graphics for beta and gamma waves associated with environmental factors and EEG electrode positions. The analysis shows that the comparative power difference between the two environments is greater for beta and gamma waves. Interestingly, lines representing the two environments in the graph were determined parallel for all electrode positions. This shows that two different environmental factors have a similar effect on all EEG electrode positions.

DISCUSSION

This study aims to investigate the physiological differences and psychological measurements of participants in modern and traditional real environments, focusing on exploring the effects of modern and historical textures, which are essential components of urban environments, on individuals. As a result of the evaluation of individual frequency bands of EEG signals, the comparison of EEG activity measured in modern and historical areas showed a significant difference in the beta and gamma bands with a significance level of 0.05.

Figure 6 shows distribution of electroencephalography (EEG) power, representation in modern and traditional environment. It is known that beta bands of EEG signals are associated with arousal, tense states, active thinking, and active attention. (Sanei & Chambers, 2013; Erkan, 2018). They are also known to have a high response to stimuli that cause negative emotions (Al Abdi *et al.*, 2018; Giannakakis *et al.*, 2019). Despite the absence of a discomforting environment, the emergence of higher beta power indicates physiological differences between the two distinct environments, suggesting that their perceptions are influenced. Kisley and Cornwell (2006) and Luo *et al*. (2007) stated that there is a correlation between beta and gamma bands, and the gamma band may increase at high cognitive levels, including sensory, auditory, and visual processes. In the study, a significant difference was found in the EEG power of the gamma bands between the two real environments, and it was observed that the EEG power of the gamma bands was higher in the participants who passed by the traditional buildings. The reason why gamma band activity is high in the examination of traditional buildings has been shown to be that they may contain more complex stimuli and therefore evoke more cognitive processes. Choi *et al.* (2015) reported that participants' alpha activity rate was relatively high in an environment with low stress, and thus alpha bands of EEG signals in the frontal lobe can be used to assess a stress-free environment. Therefore, different brain maps were recorded if the participants walking in different environments saw the areas. It has been observed that participants who see traditional areas in these maps are more active than those who see modern ones, especially in the frontal lobe (**Fig. 7**).

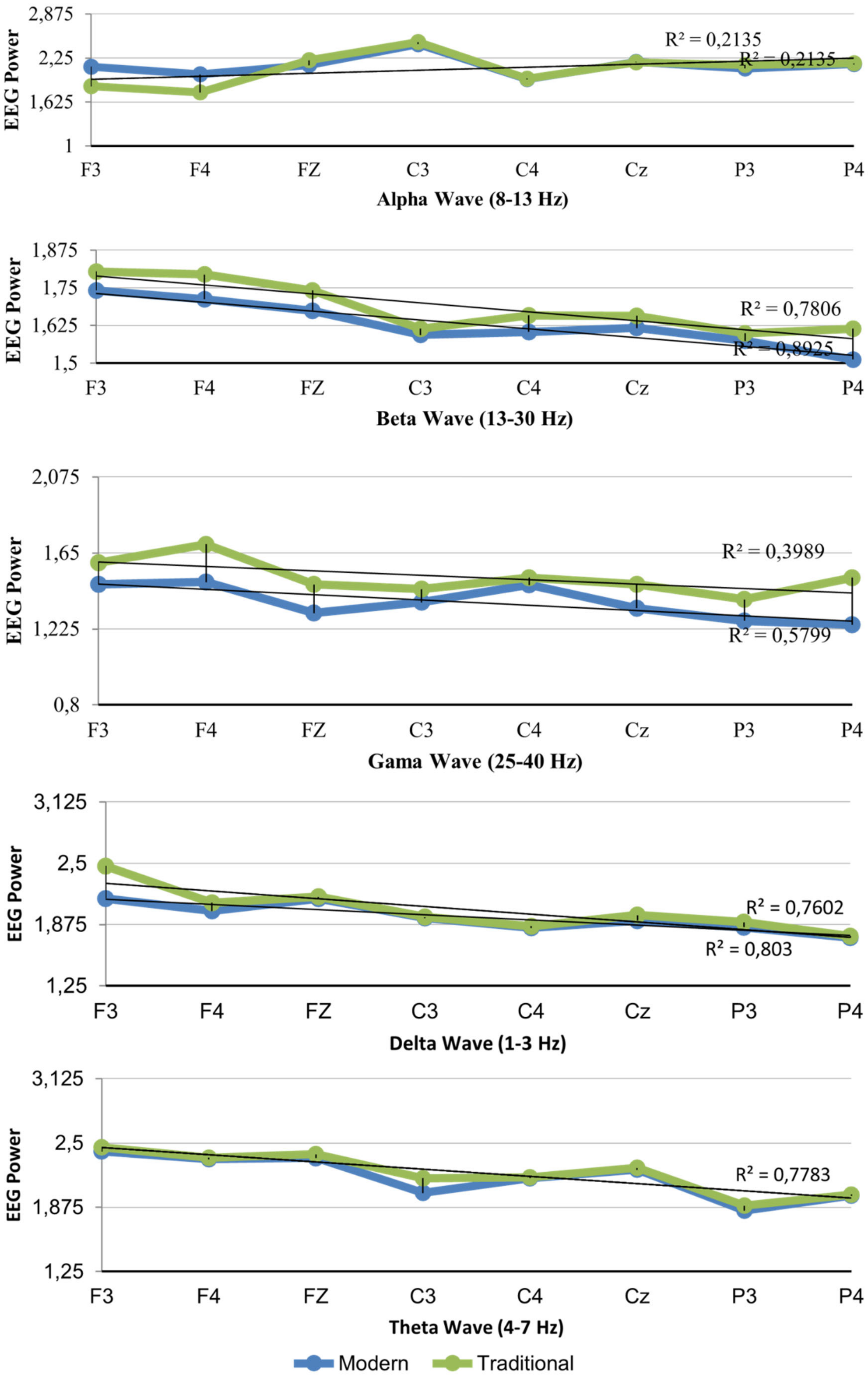

Fig. 6 Distribution of electroencephalography (EEG) power, representation in modern and traditional environment.

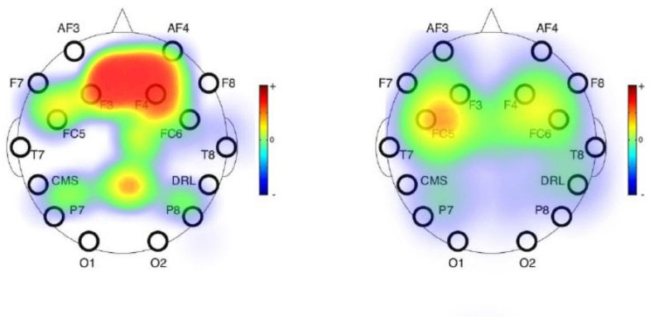

Fig. 7 The image on the left is the alpha wave in the modern environment; the right image is a topographic map of electrode probability represented for references by participants walking in the traditional setting (topographic map calculated with the mean probability for 40 subjects).

This situation also confirms the argument that two different environments containing architecturally different data are perceived differently by people. Compared to the results in the literature on gamma and alpha band activity, we encounter different data on comfort responses in the laboratory and in the field environment because the reason for the user's feel-good or satisfaction response differs according to the environmental situation. The brain activity approach in architecture and urban planning may provide clues for tracing well-being and contentment mechanisms that cannot be analyzed in traditional research methods.

Moreover, in this study, it can be questioned how the perceived spaces are perceived in the city compared to the green environment, even though the urban environment in modern and traditional environments does not evoke negative emotions or cause adverse physiological reactions. In literature, natural environmental studies are rated higher than any of them in perceived restorativeness. There are studies indicating that green areas make people feel good and even have a psychological healing effect (Rappe, 2005; Groenewegen *et al*., 2006).

Some studies in the literature (Herzog *et al*., 2003; Stigsdotter *et al*., 2017) agree that urban environments do not cause stress on their own. However, in our study, it is clear that people perceive modern and historical areas differently. However, the results regarding the urban environment and their differences from previous studies require future evaluation of the health promotion potential of urban environments with historical and architectural values. This can bring new perspective to the ongoing debate on how to create healthy cities and can also represent a strong argument for the maintenance and restoration of historic city centers.

There are many studies on the correct design of cities, from easy wayfinding (Erkan, 2024) to reducing the stress (Park & Evans, 2016) of urban life. There are studies confirming that buildings and urban areas affect us whether we are aware of their detailed geometry or not (Mallgrave, 2010; Robinson & Pallasmaa, 2015). At a very basic level, aesthetically pleasing environments attract people and are therefore known to invite people to approach them. (Goldhagen & Gallo, 2017). Manual motor movement experiments describe that movements towards something that looks more attractive are faster and more precise than movements towards unpleasant or undesirable targets, although there are even differences in running motion when people are exposed to aesthetic environments (Burtan *et al*., 2021a; Burtan *et al*., 2021b). Based on such experiments, it may be possible to impart a natural stimulus for urban movement that is positively stimulated by the attractiveness of its surroundings rather than being slowed down, stressed, or hindered by the nature of a less attractive built environment.

CONCLUSIONS

As a result of testing two different architectural understandings in the real environment, the EEG signals of the participants showed that beta and gamma band powers often increased in an environment with traditional buildings compared to an environment with modern buildings.

These results showed that the participants were relatively less stressed in a modern setting. These EEG band results can be used as an indicator of relative discomfort. The result shows that the response to comfort is not an absolute response to the environment but a relative response based on the environmental context and expectations.

Considering the results obtained from the data obtained from the study, the processes of structuring and rehabilitation of the urban environment will be valuable for the well-being of the people who use the physical environment. Depending on the scope and methodology of the conducted studies, the decision-making process in the restoration of historical buildings (decisions on the main mass, material usage, color selection, etc.), the placement of buildings within a plot, the determination of building heights specified in urban plans, the density of structures within a plot, landscape design that can positively influence the visual perception of buildings, and preferences for urban furniture usage will contribute to the creation of an effective pre-design process that can enhance the quality of the urban environment.

In addition to designing the urban texture in general, it is also important to evaluate the scale perceived by the human eye. When the results of the study were evaluated in this context, the distance of the subjects to the buildings and the human perspective were discussed. As a result of the small scale of traditional buildings compared to modern buildings, it is possible to say that the subjects can perceive the ground and first floors of modern buildings, but the entire traditional residence cannot. All the materials used in the façade setup and the traditional concept of 'residence' is perceived. In addition, the fact that the buildings may have triggered some memories of people's pasts and memories may have triggered an increase in the beta wave level in the subjects' brains when they saw the traditional buildings.

FUTURE STUDIES AND LIMITATIONS

Unlike traditional observation and survey methods, real-time measurements of brain activity and physiological and biological signals are a viable approach to generating big data containing participants' responses. It should be noted that unlike laboratory experiments, participants' reactions in the field include the condition of the field and excess stimuli, and some stimuli are not considered. These external stimuli are factors that cannot be prevented, such as bird sounds, car horns, and natural ambient noises that exist in the natural environment.

In the case of urban, given that much of the experience is visual, it is possible to examine the neuro-aesthetic effect of what is seen as a truly useful measure of urban experience (Buras, 2020). Brain activity measurements can be used to explain a participant's emotional and mental activity and to better understand the reason for the participant's familiar area. If future studies involve more participants, larger fieldwork, and data on brain activity textures, brain waves can be used as a useful indicator of well-being or contentment.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix

Appendix Table A1.

Table A1. Questions asked to the participants after the walking process

	Questions asked to the participants after the walking process
1	Are you living in this region?
2	Do you walk or jog regularly?
3	Have you ever walked this route before?
4	Which one do you prefer? a. Being in natural environment b. Being in traditional / historical environment c. Being in modern / contemporary environment

REFERENCES

Al Abdi, R. M., Alhitary, A. E., Abdul Hay, E. W., & Al-Bashir, A. K. (2018). Objective detection of chronic stress using physiological parameters. Medical & biological engineering & computing, 56, 2273-2286.

Al-Moosa, S., Allin, S., Jemiai, N., Al-Lawati, J., & Mossialos, E. (2006). Diabetes and urbanization in the Omani population: an analysis of national survey data. Population health metrics, 4, 1-8.

Alvarez, J., Angelakis, K., Rindel, J. H. (2006). A study of pleasantness and annoyance in simulated soundscapes. In 6th European Conference on Noise Control.

Aspinall, P., Mavros, P., Coyne, R., & Roe, J. (2015). The urban brain: analysing outdoor physical activity with mobile EEG. British journal of sports medicine, 49(4), 272-276.

Azimi-Nezhad, M., Ghayour-Mobarhan, M. P. M. R., Parizadeh, M. R., Safarian, M., Esmaeili, H., Parizadeh, S. M. J., ... & Ferns, G. (2008). Prevalence of type 2 diabetes mellitus in Iran and its relationship with gender, urbanisation, education, marital status and occupation. Singapore medical journal, 49(7), 571.

Badcock, N. A., Mousikou, P., Mahajan, Y., De Lissa, P., Thie, J., McArthur, G. (2013). Validation of the Emotiv EPOC® EEG gaming system for measuring research quality auditory ERPs. PeerJ, 1, e38.

Bai, X., Nath, I., Capon, A., Hasan, N., & Jaron, D. (2012). Health and wellbeing in the changing urban environment: complex challenges, scientific responses, and the way forward. Current opinion in environmental sustainability, 4(4), 465-472.

Beck, A. T., Ward, C., Mendelson, M., Mock, J., & Erbaugh, J. J. A. G. P. (1961). Beck depression inventory (BDI). Arch gen psychiatry, 4(6), 561-571.

Berlyne, D. E. (1974). Studies in the new experimental aesthetics: Steps toward an objective psychology of aesthetic appreciation. Hemisphere.

Beyer, K. M., Kaltenbach, A., Szabo, A., Bogar, S., Nieto, F. J., & Malecki, K. M. (2014). Exposure to neighborhood green space and mental health: evidence from the survey of the health of Wisconsin. International journal of environmental research and public health, 11(3), 3453-3472.

Bhugra, D., & Mastrogianni, A. (2004). Globalisation and mental disorders: overview with relation to depression. The British Journal of Psychiatry, 184(1), 10-20.

Bowler, D. E., Buyung-Ali, L. M., Knight, T. M., & Pullin, A. S. (2010). A systematic review of evidence for the added benefits to health of exposure to natural environments. BMC public health, 10(1), 1-10.

Bradley, C. A., & Altizer, S. (2007). Urbanization and the ecology of wildlife diseases. Trends in ecology & evolution, 22(2), 95-102.

Braubach, M., Egorov, A., Mudu, P., Wolf, T., Ward Thompson, C., & Martuzzi, M. (2017). Effects of urban green space on environmental health, equity and resilience. Nature-Based Solutions to Climate Change Adaptation in Urban Areas: Linkages between Science, Policy and Practice, 187-205.

Choi, Y., Kim, M., & Chun, C. (2015). Measurement of occupants' stress based on electroencephalograms (EEG) in twelve combined environments. Building and Environment, 88, 65-72.

Choo, A., May, A. (2014, October). Virtual mindfulness meditation: Virtual reality and electroencephalography for health gamification. In 2014 IEEE Games Media Entertainment (pp. 1-3). IEEE.

Chu, Y. T., Li, D., & Chang, P. J. (2021). Effects of urban park quality, environmental perception, and leisure activity on well-being among the older population. International Journal of Environmental Research and Public Health, 18(21), 11402.

Cilliers, E. J. (2015). A framework for planning green spaces in rural South Africa. Agric For Fish. Special Issue: Planning for Sustainable Communities: Green-Spaces in Rural Areas, 4, 80-86.

Debener, S., Minow, F., Emkes, R., Gandras, K., De Vos, M. (2012). How about taking a low-cost, small, and wireless EEG for a walk?. Psychophysiology, 49(11), 1617-1621.

Doğan, T., & Çötok, N. A. (2011). Oxford mutluluk ölçeği kısa formunun Türkçe uyarlaması: Geçerlik ve güvenirlik çalışması [Adaptation of the short form of the Oxford happiness questionnaire into Turkish: A validity and reliability study]. Türk psikolojik danışma ve rehberlik dergisi, 4(36), 165-172.

Eckert, S., & Kohler, S. (2014). Urbanization and health in developing countries: a systematic review. World Health Popul, 15(1), 7-20.

Ekezie, J., Anyanwu, E. G., Danborno, B., & Anthony, U. (2011). Impact of urbanization on obesity, anthropometric profile and blood pressure in the Igbos of Nigeria. North American journal of medical sciences, 3(5), 242.

Erkan, İ. (2018). Examining wayfinding behaviours in architectural spaces using brain imaging with electroencephalography (EEG). Architectural Science Review, 61(6), 410-428.

Erkan, I. (2023). A neuro-cognitive perspective on urban behavior of people with different moods. Open House International, 48(4), 822-839.

Erkan, İ. (2024). The Neuro-Cognitive Approach to Urban Planning: Wayfinding Behavior Analysis and its Effect on Urban Planning. Journal of Urban Technology, 1-27.

Farinde, A. (2013). The Beck depression inventory. The Pharma Innovation, 2(1).

Giannakakis, G., Grigoriadis, D., Giannakaki, K., Simantiraki, O., Roniotis, A., & Tsiknakis, M. (2019). Review on psychological stress detection using biosignals. IEEE Transactions on Affective Computing, 13(1), 440-460.

Grahn, P., & Stigsdotter, U. A. (2003). Landscape planning and stress. Urban forestry & urban greening, 2(1), 1-18.

Groenewegen, P. P., Van den Berg, A. E., De Vries, S., & Verheij, R. A. (2006). Vitamin G: effects of green space on health, well-being, and social safety. BMC public health, 6(1), 1-9.

Haluza, D., Schönbauer, R., & Cervinka, R. (2014). Green perspectives for public health: A narrative review on the physiological effects of experiencing outdoor nature. International journal of environmental research and public health, 11(5), 5445-5461.

Haq, S. M. A. (2011). Urban green spaces and an integrative approach to sustainable environment. Journal of environmental protection, 2(5), 601-608.

Huang, L., Said, R., Goh, H. C., & Cao, Y. (2023). The Residential Environment and Health and Well-Being of Chinese Migrant Populations: A Systematic Review. International journal of environmental research and public health, 20(4), 2968.

Ibrahim, M. M., & Damasceno, A. (2012). Hypertension in developing countries. The Lancet, 380(9841), 611-619.

James, P., Hart, J. E., Banay, R. F., & Laden, F. (2016). Exposure to greenness and mortality in a nationwide prospective cohort study of women. Environmental health perspectives, 124(9), 1344-1352.

Jenkins, R., Baingana, F., Ahmad, R., McDaid, D., Atun, R. (2011). Social, economic, human rights and political challenges to global mental health. Mental Health in Family Medicine, 8(2), 87.

Jørgensen, M. E., Borch-Johnsen, K., Witte, D. R., & Bjerregaard, P. (2012). Diabetes in Greenland and its relationship with urbanization. Diabetic Medicine, 29(6), 755-760.

Kamitsis, I., & Francis, A. J. (2013). Spirituality mediates the relationship between engagement with nature and psychological wellbeing. Journal of environmental psychology, 36, 136-143.

Khushaba, R. N., Greenacre, L., Kodagoda, S., Louviere, J., Burke, S., Dissanayake, G. (2012). Choice modeling and the brain: A study on the Electroencephalogram (EEG) of preferences. Expert Systems with Applications, 39(16), 12378-12388.

Kisley, M. A., & Cornwell, Z. M. (2006). Gamma and beta neural activity evoked during a sensory gating paradigm: effects of auditory, somatosensory and cross-modal stimulation. Clinical neurophysiology, 117(11), 2549-2563.

Kondo, M. C., Fluehr, J. M., McKeon, T., & Branas, C. C. (2018). Urban green space and its impact on human health. International journal of environmental research and public health, 15(3), 445.

Krefis, A. C., Augustin, M., Schlünzen, K. H., Oßenbrügge, J., & Augustin, J. (2018). How does the urban environment affect health and well-being? A systematic review. Urban science, 2(1), 21.

Kuzulugil, A. C., Ünsal, Ö., Yıldız, N. D., & Aytatlı, B. (2023). Space syntax-based analysis method to improve the accessibility of urban tourism in a historic environment. Journal of the Faculty of Engineering and Architecture of Gazi University, 38(4), 2359-2374.

Landorf, C. (2011). A future for the past: A new theoretical model for sustainable historic urban environments. Planning, Practice & Research, 26(2), 147-165.

Lee, E., Bailey, A. W., Hungenberg, E., Demastus, C., & Kang, H. K. (2021). Comparison of psychological states of runners within urban and nature environments: the application of electroencephalography (EEG), geographic information systems (GIS), and fitness tracker. The Social Science Journal, 1-16.

Lin, W., Chen, Q., Jiang, M., Tao, J., Liu, Z., Zhang, X., ... & Zeng, Q. (2020). Sitting or walking? Analyzing the neural emotional indicators of urban green space behavior with mobile EEG. Journal of Urban Health, 97, 191-203.

Liu, Q., Wang, X., Liu, J., Zhang, G., An, C., Liu, Y., ... & Zhang, H. (2021). The relationship between the restorative perception of the environment and the physiological and psychological effects of different types of forests on university students. International Journal of Environmental Research and Public Health, 18(22), 12224.

Liu, Z., Liu, L., Li, Y., & Li, X. (2023). Influence of urban green space landscape pattern on river water quality in a highly urbanized river network of Hangzhou city. Journal of Hydrology, 129602.

Luo, Q., Holroyd, T., Jones, M., Hendler, T., & Blair, J. (2007). Neural dynamics for facial threat processing as revealed by gamma band synchronization using MEG. Neuroimage, 34(2), 839-847.

Maas, J., Verheij, R. A., Groenewegen, P. P., De Vries, S., & Spreeuwenberg, P. (2006). Green space, urbanity, and health: how strong is the relation? Journal of epidemiology & community health, 60(7), 587-592.

Matthews, G.; Jones, D.M.; Chamberlain, A.G. Refining the measurement of mood: The UWIST Mood Adjective Checklist. Br. J. Psychol. 1990, 81, 17–42

Mavros, P., J Wälti, M., Nazemi, M., Ong, C. H., & Hölscher, C. (2022). A mobile EEG study on the psychophysiological effects of walking and crowding in indoor and outdoor urban environments. Scientific reports, 12(1), 18476.

McConnachie, M. M., & Shackleton, C. M. (2010). Public green space inequality in small towns in South Africa. Habitat international, 34(2), 244-248.

Menshawy, M. E., Benharref, A., Serhani, M. (2015). An automatic mobile-health based approach for EEG epileptic seizures detection. Expert systems with applications, 42(20), 7157-7174.

Mexia, T., Vieira, J., Príncipe, A., Anjos, A., Silva, P., Lopes, N., ... & Pinho, P. (2018). Ecosystem services: Urban parks under a magnifying glass. Environmental research, 160, 469-478.

Milosevic, M., Milenkovic, A., Jovanov, E. (2013). mHealth@ UAH: computing infrastructure for mobile health and wellness monitoring. XRDS: Crossroads, The ACM Magazine for Students, 20(2), 43-49.

Moore, M., Townsend, M., & Oldroyd, J. (2006). Linking human and ecosystem health: The benefits of community involvement in conservation groups. EcoHealth, 3, 255-261.

Murugappan, M., & Murugappan, S. (2013, March). Human emotion recognition through short time Electroencephalogram (EEG) signals using Fast Fourier Transform (FFT). In 2013 IEEE 9th International Colloquium on Signal Processing and its Applications (pp. 289-294). IEEE.

Murugappan, M., Murugappan, S., & Gerard, C. (2014, March). Wireless EEG signals based neuromarketing system using Fast Fourier Transform (FFT). In 2014 IEEE 10th international colloquium on signal processing and its applications (pp. 25-30). IEEE.

Neale, C., Aspinall, P., Roe, J., Tilley, S., Mavros, P., Cinderby, S., ... Thompson, C. W. (2017). The aging urban brain: analyzing outdoor physical activity using the emotiv affectiv suite in older people. Journal of Urban Health, 94(6), 869-880.

Neale, C., Aspinall, P., Roe, J., Tilley, S., Mavros, P., Cinderby, S., ... & Ward Thompson, C. (2020). The impact of walking in different urban environments on brain activity in older people. Cities & health, 4(1), 94-106.

Olszewska-Guizzo, A., Sia, A., Fogel, A., & Ho, R. (2020). Can exposure to certain urban green spaces trigger frontal alpha asymmetry in the brain? Preliminary findings from a passive task EEG study. International Journal of Environmental Research and Public Health, 17(2), 394.

Othman, N., Salleh, M. Z. M., Malek, N. A., & Suddin, L. S. (2020). An Overview of Psychological Restoration in Urban Environment: Integration of Pro-Environmental Theory into Neuro-Landscape Study. Journal of ASIAN Behavioural Studies, 5(16), 1-17.

Park, G., & Evans, G. W. (2016). Environmental stressors, urban design and planning: implications for human behaviour and health. Journal of Urban Design, 21(4), 453-470.

Pacione, M. (2003). Urban environmental quality and human wellbeing—a social geographical perspective. Landscape and urban planning, 65(1-2), 19-30.

Panagopoulos, T., Duque, J. A. G., & Dan, M. B. (2016). Urban planning with respect to environmental quality and human well-being. Environmental pollution, 208, 137-144.

Pauchard, A., Aguayo, M., Peña, E., & Urrutia, R. (2006). Multiple effects of urbanization on the biodiversity of developing countries: the case of a fast-growing metropolitan area (Concepción, Chile). Biological conservation, 127(3), 272-281.

Phillips, D. R. (1993). Urbanization and human health. Parasitology, 106(S1), S93-S107.

Pirgon, Ö., & Aslan, N. (2015). The role of urbanization in childhood obesity. Journal of clinical research in pediatric endocrinology, 7(3), 163.

Popkin, BM (1999). Kentleşme, yaşam tarzı değişiklikleri ve beslenme geçişi. Dünya gelişimi, 27 (11), 1905-1916.

Pretty, J. (2004). How nature contributes to mental and physical health. Spirituality and Health International, 5(2), 68-78.

Qin, J., Zhou, X., Sun, C., Leng, H., & Lian, Z. (2013). Influence of green spaces on environmental satisfaction and physiological status of urban residents. Urban Forestry & Urban Greening, 12(4), 490-497.

Reece, R., Bornioli, A., Bray, I., & Alford, C. (2022). Exposure to green and historic urban environments and mental well-being: results from EEG and psychometric outcome measures. International journal of environmental research and public health, 19(20), 13052.

Richardson, E. A., Pearce, J., Mitchell, R., & Kingham, S. (2013). Role of physical activity in the relationship between urban green space and health. Public health, 127(4), 318-324.

Roe, J. J., Thompson, C. W., Aspinall, P. A., Brewer, M. J., Duff, E. I., Miller, D., ... & Clow, A. (2013). Green space and stress: evidence from cortisol measures in deprived urban communities. International journal of environmental research and public health, 10(9), 4086-4103.

Sadeghi, A. R., Ebadi, M., Shams, F., & Jangjoo, S. (2022). Human-built environment interactions: the relationship between subjective well-being and perceived neighborhood environment characteristics. Scientific Reports, 12(1), 21844.

Sampson, L., Ettman, C. K., & Galea, S. (2020). Urbanization, urbanicity, and depression: a review of the recent global literature. Current opinion in psychiatry, 33(3), 233-244.

Sanei, S., & Chambers, J. A. (2013). EEG signal processing. John Wiley & Sons.

Schäfer, P. J., Serman, M., Arnold, M., Corona-Strauss, F. I., Strauss, D. J., Seidler-Fallböhmer, B., & Seidler, H. (2015, August). Evaluation of an objective listening effort measure in a selective, multi-speaker listening task using different hearing aid settings. In 2015 37th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC) (pp. 4647-4650). IEEE.

Selmi, W., Weber, C., Rivière, E., Blond, N., Mehdi, L., & Nowak, D. (2016). Air pollution removal by trees in public green spaces in Strasbourg city, France. Urban forestry & urban greening, 17, 192-201.

Sugiyama, T., Leslie, E., Giles-Corti, B., & Owen, N. (2008). Associations of neighbourhood greenness with physical and mental health: do walking, social coherence and local social interaction explain the relationships? Journal of Epidemiology & Community Health, 62(5), e9-e9.

Tae, J., Jeong, D., & Chon, J. (2022). How Can Apartment-Complex Landscaping Space Improve Residents' Psychological Well-Being?: The Case of the Capital Region in South Korea. International journal of environmental research and public health, 19(16), 10231.

Teplan, M. (2002). Fundamentals of EEG measurement. Measurement science review, 2(2), 1-11.

Thompson, C. W., Roe, J., Aspinall, P., Mitchell, R., Clow, A., & Miller, D. (2012). More green space is linked to less stress in deprived communities: Evidence from salivary cortisol patterns. Landscape and urban planning, 105(3), 221-229.

Van den Berg, A. E., Maas, J., Verheij, R. A., & Groenewegen, P. P. (2010). Green space as a buffer between stressful life events and health. Social science & medicine, 70(8), 1203-1210.

Van Kamp, I., Leidelmeijer, K., Marsman, G., & De Hollander, A. (2003). Urban environmental quality and human well-being: Towards a conceptual framework and demarcation of concepts; a literature study. Landscape and urban planning, 65(1-2), 5-18.

Velarde, M. D., Fry, G., & Tveit, M. (2007). Health effects of viewing landscapes–Landscape types in environmental psychology. Urban forestry & urban greening, 6(4), 199-212.

Voss, J. D., Masuoka, P., Webber, B. J., Scher, A. I., & Atkinson, R. L. (2013). Association of elevation, urbanization and ambient temperature with obesity prevalence in the United States. International journal of obesity, 37(10), 1407-1412.

Vujcic, M., Tomicevic-Dubljevic, J., Grbic, M., Lecic-Tosevski, D., Vukovic, O., & Toskovic, O. (2017). Nature based solution for improving mental health and well-being in urban areas. Environmental research, 158, 385-392.

Wang, R., Xue, D., Liu, Y., Chen, H., & Qiu, Y. (2018). The relationship between urbanization and depression in China: the mediating role of neighborhood social capital. International journal for equity in health, 17, 1-10.

Wu, J., Zhong, Y., Wang, Y., Gong, C. (2022). Investigating the Relation between Visitor Attention and Visual Quality of Forest Landscape: A Mobile EEG Study. Forests, 13(10), 1668.

Yang, Y., Chen, H., Al, M. A., Ndayishimiye, J. C., Yang, J. R., Isabwe, A., ... & Yang, J. (2022). Urbanization reduces resource use efficiency of phytoplankton community by altering the environment and decreasing biodiversity. journal of environmental sciences, 112, 140-151.

Zhang, B., Gao, J. X., & Yang, Y. (2014). The cooling effect of urban green spaces as a contribution to energy-saving and emission-reduction: A case study in Beijing, China. Building and environment, 76, 37-43.

Zhang, J., Zheng, Y., Wen, T., Yang, M., & ming Feng, Q. (2022). The impact of built environment on physical activity and subjective well-being of urban residents: A study of core cities in the Yangtze River Delta survey. Frontiers in Psychology, 13.

Zhang, W., Yang, J., Ma, L., & Huang, C. (2015). Factors affecting the use of urban green spaces for physical activities: Views of young urban residents in Beijing. Urban Forestry & Urban Greening, 14(4), 851-857.