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Sitting or Walking? Analyzing the Neural Emotional Indicators of Urban Green Space Behavior with Mobile EEG

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Abstract There is a close relationship between urban green space and the physical and mental health of individuals. Most previous studies have discussed the impact of the structure of green space and its elements. This study focused on the emotional changes caused by common behaviors in urban green space (walking and sitting). We recruited 40 college students and randomly assigned them to walking and sitting groups (20 students per group). The two groups performed the same 8-min high-pressure learning task indoors and then performed 8-min recovery activities in a simulated urban green space (a bamboo-lawn space). We used the Emotiv EPOC+ EEG headset to dynamically measure six neural emotional parameters: "engagement," "valence," "meditation," "frustration," "focus," and "excitement." We conducted a pretest and posttest and used analysis of covariance (ANCOVA) to analyze the posttest data (with the pretest data as covariates). The results of the comparison of the two behaviors showed that the "valence" and "meditation" values of the walking group were higher than those of the sitting group, which suggests that walking in urban green space is more favorable for stress reduction. The sitting group had a higher "focus" value than did the walking group, which suggests that sitting in urban green space is better for attention restoration. The results of this study can provide guidance for urban green space planning and design as well as health guidance for urban residents.

Keywords Behaviour · EEG · Emotion

Introduction

To date, the process of urbanization continues worldwide [1]. Fast-paced life and high-intensity work bring

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more physical and mental stress to urban residents [2, 3]. The green environment plays a significant positive role in stress reduction and attention restoration [4, 5]. There is a close interaction between urban green space and urban residents, and the urban green space plays an important role in helping urban residents remain healthy [6, 7]. Most previous studies have used green space as the object and have focused on its structural characteristics [8, 9] and elemental characteristics [10, 11]. Some researchers have used urban residents as objects and have studied their subjective behaviors and physiological and psychological activities [12, 13]. In general, however, previous studies have paid less attention to humans, who are nonetheless an important part of the relationship between urban green space and the population of urban residents. In particular, the behavior in which individuals engage deserves more attention. Urban green space behavior is an important link between humans and green space. Urban green space behavior is a non-negligible factor that has important value in guiding planning and design.

There are many methods with which to evaluate the health benefits of green space. The two main differences among these methods are the stimulus conditions and evaluation criteria. The premise of this study is that behavior functions as the link between urban residents and urban green space. The theoretical basis of this research includes the physiological recovery effect of green space and the objectivity of the electroencephalogram (EEG) to reflect physiological activities [14, 15]. In this study, the evaluation of emotional activity based on EEG data was proposed to link human behavior with urban green space. The following is an elaboration of the relevant theories and relationships.

The Relationship between Urban Green Space and Human Behavior

In densified cities, urban green space provides a valuable outdoor environment for individuals. The urban green space that results from scientific planning and design has a guiding effect on outdoor activities and thus affects individuals' behavior. For example, previous studies have pointed out that the layout and structure of urban green space have a key impact on outdoor activities [16, 17] and are closely related to many health conditions [18, 19]. Conversely, behavior can also affect urban green space. Common behaviors in urban green space, such as walking and sitting, are closely related to the planning of walking space and seating in green space. In his social communication space theory, Gehl et al. proposed that spontaneous human activities, such as walking and sitting, are the premise and basis of social activities [20]. Therefore, the study of activities such as walking and sitting is of great value to the basic research of spontaneous behavior and health and can provide guidance and a theoretical basis for urban green space construction.

Previous studies have confirmed that walking activities in urban green spaces can result in lower heart rates and heart rate variability [12, 21] and better mood [5] than walking in other urban environments. There have been more studies on sitting in green spaces than on walking in such spaces. Goto et al. compared heart rate and emotional changes in elderly individuals in different green spaces [22], and Igarashi et al. studied heart rate variability in students sitting in green space [13]. These studies focused on the relationship between behavior and psychophysiological indicators, and all of these studies suggested the health effects of green space behavior based on particular indicators. However, the number of such studies is small, and there is a lack of research comparing different behaviors. In studies of physiological and psychological indicators, there are two important theories, namely, attention restoration theory (ART) [23–25] and stress reduction theory (SRT) [26]. Studies have shown that individuals exposed to green space experience a degree of attention recovery [27–30]. In addition, physiological and psychological stress levels can be reduced, specifically embodied in physiological indicators, such as blood pressure and heart rate, and emotional and other psychological indicators [5, 13, 31, 32]. In previous studies, green space experiments are often carried out in a single behavior mode. To date, few studies have compared green space behaviors.

The Appraisal of Psychophysiological Responses to Urban Green Space

In previous studies on green space, evaluations have mainly been based on physiological and psychological aspects. First, in terms of the stimuli used in these studies, many researchers have used photographs [14, 27]. To make the photographs more realistic, some studies have used larger screens or 3D glasses [33]. Other researchers have directly arranged conditions such that subjects enter the actual environment, such as urban green space [10], a city square [29], or a city street [12]. The three types of methods have their own advantages. The use of photographs can help eliminate interference from other factors, which the actual environment cannot, but the sense of reality derived from the photograph is lower than that from the actual scene. Studies that employ real green space as a stimulus typically explore the horizontal comparison of the same type of space. For example, Qin et al. studied the psychological satisfaction and physiological indicators of different age groups for several plant spaces [10]. In addition, the teams of San Juan and Aspinall carried out field psychophysiological measurements at several sampling points, one for the square and the other for the street [12, 29]. The advantage of using real green space as a stimulus lies in the authenticity. However, because of the large number of factors in space, it is impossible to conduct a particular study on a particular variable. VR and 3D glasses can provide a more realistic visual experience, but the environment is still different from the real environment. In addition, another approach is to set up a scene simulation experiment; for example, Choi et al. regulated the amount of green plants in an indoor space to explore the physiological and psychological effects of the green index as a single variable [34].

Second, the evaluation aspects have mainly been divided into physiological and psychological indicators. Heart rate, heart rate variability, blood pressure, pulse, and EEG data have commonly been used as physiological indicators [6, 22, 27], while psychological indicators have focused mainly on emotion, preference, and attention [35–37]. Physiological indexes are a type of direct evaluation that is more objective than the psychological questionnaire. The advantage of psychological questionnaires lies in the diversity and richness of the indicators used, such as the Profile of Mood States (POMS), which is commonly used by researchers. In conclusion, previous studies have used different methods in terms of stimulus sources and evaluation criteria, but if they are to be applied to the study of urban green space behavior, the advantages of existing methods must be integrated.

EEG and the Neural Emotional Indicators

Emotional activity is an important aspect that is widely regarded in the study of green space. Based on objective physiological data, the electroencephalogram (EEG) has been widely used in previous studies of green space restoration [27, 38]. Some previous studies have focused on the neural emotional parameters of walkers in an urban environment using a mobile multichannel EEG device (Emotiv EPOC+) [12, 38, 39]. These parameters were determined by the device's conversion of brain waves rather than by the subject's subjective evaluation. It has been suggested that the accuracy of the mobile EEG device is appropriate for research [40–43]. The Emotiv EPOC+ device provides measures of six neural emotional parameters: "engagement," "valence," "meditation," "frustration," "focus," and "excitement." In the study of Aspinall et al., five neural emotional parameters provided by the Emotiv EPOC+ device were used to compare the status differences of walkers in three urban areas [12]. The results of that study confirmed the positive effects of walking in urban green spaces compared to the other two environments. It also indicates the feasibility of neural emotional parameters used in horizontal comparison experiments. Neale et al.'s study focused on the elderly, and they further verified the better performance of an urban green belt on neural emotional parameters through the two-way walking route experiment [38, 39]. These previous studies used Emotiv EPOC+ devices' emotional indicators to study walking, and the positive effect of green walking has been well verified. This study investigates the differences between different green space behaviors through neural emotional parameters. At the same time, this study employs ART and SRT to discuss the reason for the differences.

To facilitate quantitative evaluation, researchers in the field of emotional computing have proposed multidimensional models [44]. Among these models, the most common models are the pleasure-arousal-dominance model (PAD) [45], the evaluation-activity-power model (EAP) [46], and the arousal-valence model (A-V) [47]. The arousal-valence model (Fig. 1) has been widely used for emotion evaluation. The arousal dimension indicates the degree of activation, and the valence dimension indicates the degree of pleasure. Based on psychological and neuroscience research, it has been suggested that the responses along the dimensions of arousal and valence are correlated with activity in particular regions of the brain [48, 49]. Ramirez et al. combined assessments of brain waves with the emotion arousal-valence model (A-V) in his study of auditory perception [50]. By combining previous research on the brain and brain activity [51–53], the levels of arousal and valence were calculated by the following formula in Ramirez et al.'s research: $\text{Arousal} = (\beta F3 + \beta F4 + \beta AF3 + \beta AF4) / (\alpha F3 + \alpha F4 + \alpha AF3 + \alpha AF4)$;

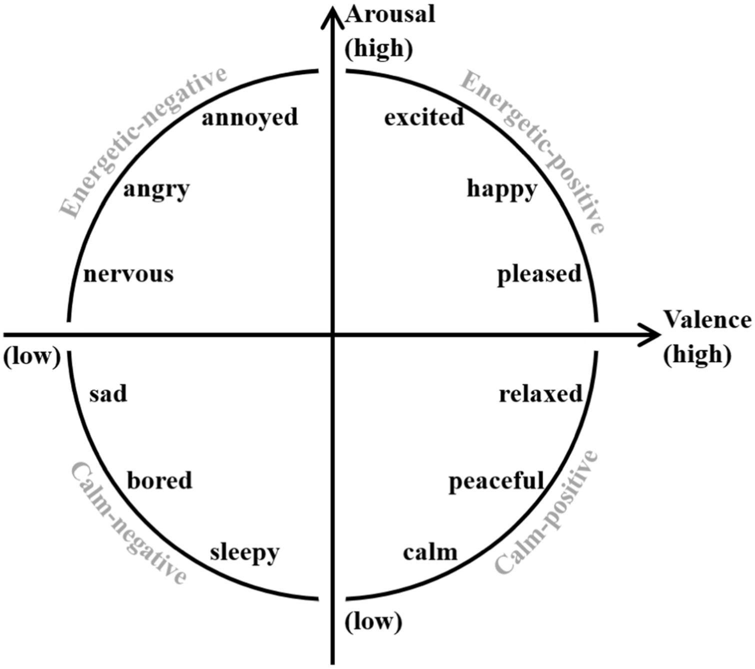

Fig. 1 Arousal-valence emotion model

Valence = αF4 − αF3. In the formulas, F3, F4, AF3, and AF4 are the electrodes of the Emotiv EPOC+ device in the frontal lobe of the brain (international 10–20 system) [50]. β waves and α waves correspond to excited and inactive brain states, respectively. This will support the hypothesis of this study.

Aims and Hypotheses

The purpose of this study is to compare the differences between the two behaviors in neural emotional indicators to provide references for healthy green space behaviors and green space planning and design.

This study refers to the previous study of Emotiv EPOC+, Emotiv's explanation, and the classic arousal-valence emotion model, to present the working definitions of each emotional parameter: "Engagement" is similar to "arousal" in the classic arousal-valence emotion model, which reflects the degree of immersion, investment or attraction. "Valence," namely, "valence" in the classic arousal-valence emotion model, reflects the degree of positive emotion. "Meditation" is a low state of arousal, but the extent of the valence cannot be determined, and it manifests the sense of rest or sleep. "Frustration" is the state of low valence, but the degree of arousal cannot be determined, indicating disappointment and a negative sense. "Focus" is a high state of arousal, reflecting high attention, but the extent of the valence cannot be determined. "Excitement" is a superposition of the high-arousal and valence states.

Based on the consideration of previous studies using the Emotiv EEG device [12, 39] and the emotion model studies, we propose the following expectations: in urban green space, the values of "engagement," "frustration," and "excitement" while walking will be higher than those while sitting, and the values of "valence," "focus," and "meditation" while sitting will be higher than those while walking.

Methods

Experimental Locations

The experiment had two stages. The pretest was conducted indoors, and the posttest was conducted outdoors. The two adjacent experimental sites were arranged in a classroom and an external environment at Sichuan Agricultural University, China (103° 51′ 39″ E, 30° 42′ 22″ N, 512 m). A classroom with a window on the south side (10 m long, 5 m wide, and 4 m high) was selected for the pretest, and the testing position was facing the wall. The room was well ventilated and quiet to ensure no interference. The green space of the posttest was set near the classroom and was made into a simulated urban green space surrounded by a bamboo forest (15 m long and 8 m wide). Bamboo is a well-liked plant in China and is an excellent plant for creating isolation. Simulated urban green space is an experimental environment, which is a closed environment shaped by artificial control of experimental variables in the real environment. Previous researchers have used photographs or real-life urban green spaces as stimuli. Due to the low sense of reality in the photographs and the random factors that occur with real-life urban green spaces, we instead adopted a simulated space as the stimulus. The aim of the simulation space was to create a real sense of urban green space as much as possible while simultaneously reducing interference from random factors outside the experimental variables. The experiment was conducted in September 2018. We decided in advance whether or not to carry out the experiment on each day according to the weather forecast. The test was conducted from 10:00 am to 12:00 pm on each experimental day. Moreover, to enable termination of the experiment when the climate changed too substantially, we conducted real-time climate monitoring in the outdoor space (posttest) during the experiment. Finally, we obtained the outdoor climate range during all experimental days: temperature (20–25 °C), humidity (52–68%), wind speed (0–1.2 m/s), and solar radiation (67–108 W/m^2). The indoor temperature, humidity, and illumination were maintained at 22 °C, 55%, and 500 lux, respectively.

Participants

We recruited 40 college students, among whom 45% were male and 55% were female, via campus posters. The subjects were mostly from cities in southwest China, and a few subjects were from rural areas but had at least 5 years of urban life experience. Therefore, they had a cognitive basis for experience with urban green space. Because previous studies have noted that professionals' perception of space differs from that of nonprofessionals [54], we did not choose landscape architecture students as subjects. We wanted subjects to be more representative of the general population. The participants' mean age was 20.5 years (range = 18–24, SD = 1.87), and their body mass index (BMI) was within the normal range (range = 18.5–23.9). No participants smoked or had a history of mental illness, and all participants completed the preexperiment questionnaires (i.e., the Social Anxiety Subscale of the Self-Consciousness Scale, the Shyness Scale, and the State-Trait Anxiety Inventory Form Y (STAI-FORM Y)). Bamboo is a common plant in China, especially in the region where this experiment was conducted. Before the experiment, all participants were fully informed of the study and voluntarily provided informed consent. All subjects had a clear understanding of bamboo forests and this experiment.

EEG Data Acquisition

We used the Emotiv EPOC+ EEG headset to collect brainwave signals. Numerous studies have confirmed the accuracy of the equipment [15, 40, 41, 43]. The device is noninvasive and has the advantage of multichannel acquisition with 14 electrodes (AF3, AF4, F3, F4, F7, F8, FC5, FC6, T7, T8, P7, P8, O1, and O2). P3 and P4 were reference electrodes. Electrode impedances were kept below 5 kΩ. The signals were internally sampled at 1024 Hz and were internally down sampled to 128 Hz per channel. EEG data collected by the electrodes were sent to a computer hard disk through Bluetooth. Then, the EmotivPro Affectiv suite analyzed the EEG activity and output performance metrics data for six neural emotional parameters ("engagement," "valence," "meditation," "frustration," "focus," and "excitement"). The parameters were normalized for each individual and scaled to fit on a scale of 0 to 1. The scaling was based on a successive approximation of the mean and variance for each recording calculated as the session progressed. This process resulted in approximately seven samples per second (7 Hz) [39].

Procedure and Statistical Analysis

All subjects were randomly assigned to the walking and sitting groups, which were both administered the same 8 min of high-stress tasks in the pretest. The subjects were directed to the test area in the classroom, where they put on the EEG device. The first part of the task comprised foreign language translation and advanced mathematics calculations, which were much more difficult than the college standard. The subjects were instructed to complete the process quickly, which increased their stress [33, 55, 56]. The second section included the Trail Making Test (TMT), which includes connecting lines and putting random numbers in order to sustain participants' attention [57, 58].

The posttest was conducted in the simulated green space, and the test time was 8 min for each round. Because urban green space is a public environment used by many individuals at the same time, 3 subjects participated in green space activities at the same time in each round of the experiment (2 subjects in the last round). The interval between the pretest and posttest was controlled within 5 min. During this time, the assistant guided the subjects to the posttest site, confirmed that the EEG device was functioning properly, explained certain requirements (such as not communicating with other individuals or leaving the site), and helped them prepare to begin the test. The subjects in the walking group carried a computer on their back and walked, and their routes were not fixed but were completely random [12]. The subjects in the sitting group randomly chose their seats before the experiment began and were asked not to leave their seats during the experiment. They were allowed to turn their heads in their seats to enjoy the view or make other natural and comfortable movements. Each round of the experiment was controlled within 40 min, including the time for wearing and linking the equipment, moving to the site and the unfixed intermediate time (Fig. 2).

To determine the differences between the two behaviors in terms of the impact of the six neural emotional parameters, analysis of covariance (ANCOVA) was employed to analyze differences between the two groups' posttest results. The function of the pretest is to play the role of the baseline measurement, and the pretest results were used as covariates to avoid the effect of the different individual states. SPSS 22.0 software was used for the analysis. In addition, we used the minute-by-minute dynamic values to further observe the differences between the sitting group and walking group.

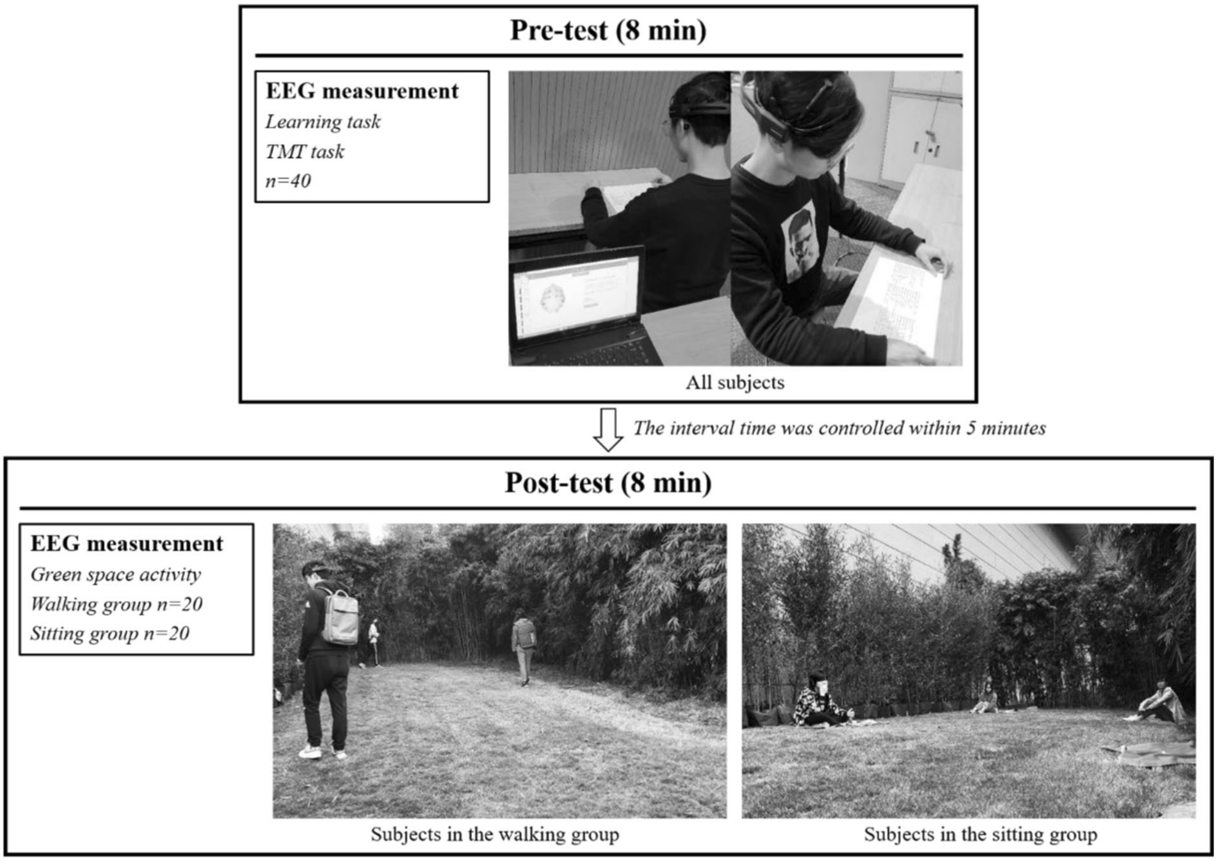

Fig. 2 Study procedure

Results

The ANCOVA showed that the “valence” and “meditation” results of the walking group ($M = 0.71$ and 0.58, respectively) were significantly higher than those of the sitting group ($M = 0.63$ and 0.33, respectively), and the “focus” results of the walking group ($M = 0.42$) were significantly lower than those of the sitting group ($M = 0.55$). The other three neural emotional parameters showed no significant differences between the sitting group and walking group. The values of all neural emotional parameters are shown (Fig. 3), and the results of the ANCOVA are shown Table 1.

The minute-by-minute dynamic parameter values further showed the differences in the process (Fig. 4). “Valence” and “meditation” showed consistent results, with higher values per minute in the walking group, whereas “Focus” showed higher values per minute in the sitting group. The dynamic results of the three parameters are consistent with the results of the ANCOVA.

Discussion

Several test results differed from our expectations. We noted that these outcomes were associated with stress reduction and attention restoration. On the one hand, “valence” and “meditation” in the walking group were higher than those in the sitting group, which indicates that the relaxation effect of walking in urban green space was better. On the other hand, the sitting group had a higher “focus,” which suggests a higher degree of emotional arousal than walking and a better recovery of attention. Attention restoration theory (ART) [23] and stress reduction theory (SRT) [26] have been proposed and widely applied in previous studies. In addition, we believe that the experimental results were due to the setup of the simulation experiment, such as the size and biodiversity of the space.

From the Perspectives of ART and SRT

We observed that the walking group showed two significantly higher neural emotional parameters—namely, “valence” and “meditation”—and that these results were consistent throughout the entire testing period. Our working definition offers a description of these changes; namely, the valence of emotion was enhanced, and the arousal of emotion was diminished. These findings indicate that stressed humans can obtain more emotional relaxation and stress relief by walking than sitting in urban green spaces. From previous studies, we found that there is a close relationship among green space behavior, sensory perception processes, and psychophysiological feedback. First, SRT asserts that stress involves multiple psychological aspects (e.g.,

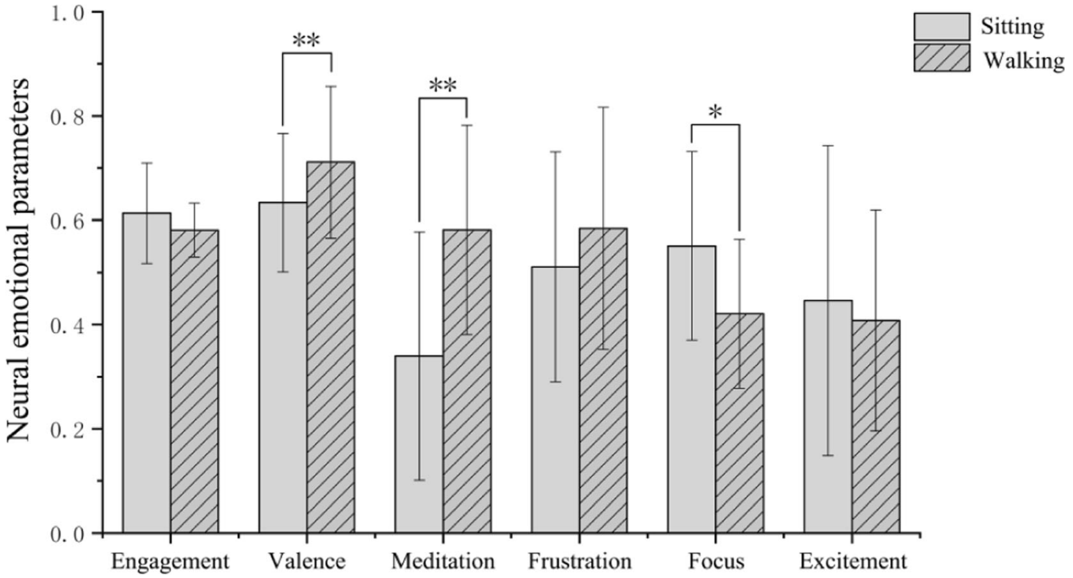

Fig. 3 Values of neural emotional parameters of the sitting group and walking group ($N = 20$; mean ± standard error; *$p < 0.05$; **$p < 0.01$)

Table 1 Results of ANCOVA comparing the six neural emotional parameters between the walking group and sitting group (covariates: pretests; dependent variables: posttests)

Neural emotional parameters	Sum of squares	df	Mean square	F	Sig.	Partial η^2	Pairwise comparisons
Engagement							
Pretest	0.040	1	0.040	7.847	0.008	0.175	
Behavior	0.008	1	0.008	1.652	0.207	0.043	
Error	0.187	37	0.005				
$R^2 = 0.211$ (adj $R^2 = 0.168$)							
Valence							
Pretest	0.188	1	0.188	12.639	0.001	0.255	
Behavior	0.123	1	0.123	8.269	0.007**	0.183	S < W
Error	0.551	37	0.015				
$R^2 = 0.311$ (adj $R^2 = 0.273$)							
Meditation							
Pretest	0.312	1	0.312	7.528	0.009	0.169	
Behavior	0.669	1	0.669	16.140	0.000**	0.304	S < W
Error	1.534	37	0.041				
$R^2 = 0.369$ (adj $R^2 = 0.335$)							
Frustration							
Pretest	0.462	1	0.462	11.487	0.002	0.237	
Behavior	0.059	1	0.059	1.456	0.235	0.038	
Error	1.488	37	0.040				
$R^2 = 0.258$ (adj $R^2 = 0.218$)							
Focus							
Pretest	0.098	1	0.098	3.964	0.054	0.097	
Behavior	0.160	1	0.160	6.497	0.015*	0.149	S > W
Error	0.913	37	0.025				
$R^2 = 0.226$ (adj $R^2 = 0.184$)							
Excitement							
Pretest	0.059	1	0.059	0.879	0.355	0.023	
Behavior	0.007	1	0.007	0.099	0.754	0.003	
Error	2.474	37	0.067				
$R^2 = 0.029$ (adj $R^2 = -0.024$)							

S indicates the sitting group. W indicates the walking group. *$p < 0.05$; **$p < 0.01$

environmental cognition, fear, anger, and sadness) and physiological aspects (e.g., cardiovascular, skeletal muscle, and neuroendocrine systems) [26]. Second, Kennedy et al.'s research argued that the response to environmental stress is influenced by behavior, but additional research is needed to reveal changes in the nervous, endocrine, and immune systems that result from exposure to visual and auditory stimuli [26,]. In addition, Hartig et al.'s research compared different behaviors in urban green space, and his results were consistent with the results of this study. In Hartig's experiment, blood pressure was used as an indicator, and walking over a period of time was better at lowering blood pressure than sitting, which suggests that walking was more relaxing in that situation [5]. Based on these theories, in our study, the neural emotional parameters were obtained through the brain waves from four brain regions, which were measured by a multichannel EEG device. These four brain regions control emotion and behavior, memory and language processing, sensory connectivity, and visual information [14]. Thus, the results were strongly associated with sensory perception

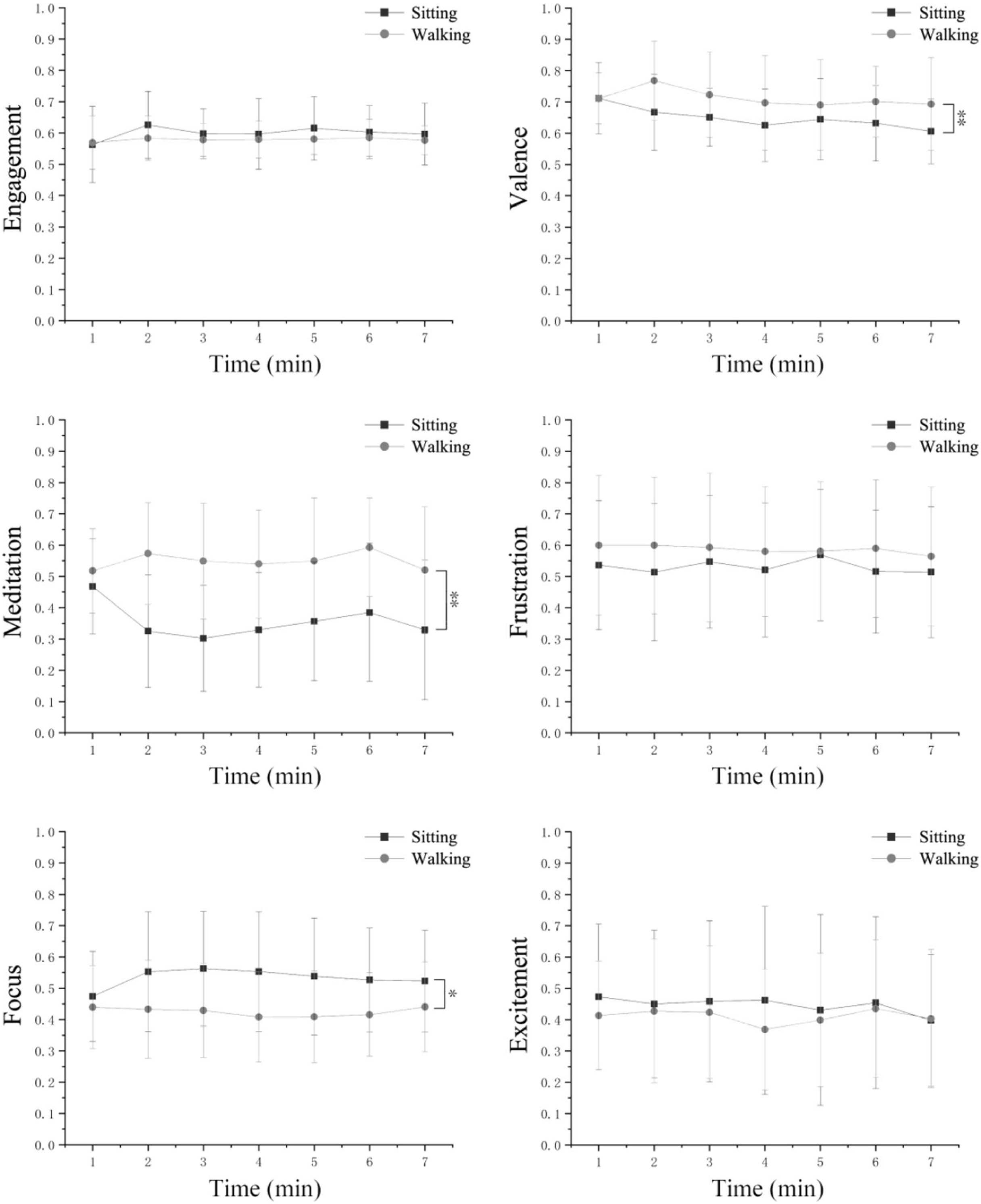

Fig. 4 Minute-by-minute dynamic values of the neural emotional parameters of the sitting group and walking group ($N = 20$; mean ± standard error; *$p < 0.05$; **$p < 0.01$)

processes. First, walking results in more varied visual stimulation, including more dynamic images and random landscapes, than sitting. Moreover, walking is psychologically less restrictive than sitting. These factors could be linked to reductions in stress.

We believe that the reason why the “focus” index of the sitting group is higher than that of the walking group is due to the “green environment” and “independent space” of the experimental space. Previous studies with ART have shown that attention restoration is linked to the proportion and continuity of the greenness [34]. At the same time, the closed space constructed in this experiment forms an independent green space, which makes the individuals feel like they have “been away” from the urban built environment for a while [60]. The green landscape viewed by sitting is more sustainable and stable, which may be more in line with the “extent” factor (continuity) emphasized by ART [23]. Relatively stable and coherent green landscapes should be more conducive to attention restoration than frequently changing green landscapes. In addition, because of the fast pace of life and work in cities, the short-term effects of exposure to urban green spaces have become more important. Hallgrimsdottir et al.’s research has proven that a short period of green space exposure contributed to attention restoration [61]. Our experiments also showed that short-term (8-min) urban green space walking or sitting was beneficial.

From the Perspectives of Outdoor Space Theory and Biodiversity

The “engagement,” “excitement,” and “frustration” indexes did not show significant differences between the sitting group and walking group. “Engagement” and “excitement” indicate the degree of arousal. Gehl et al.’s spatial communication theory suggests that humans communicating with others is a basic aspect of human nature [20], while the theory of American anthropologist Edward Hall defines the distance of communication [62]. Although each round of this study included three subjects participating at the same time, they were forbidden to communicate with each other to reduce random variables in the experiment, which can be inferred to have made the green space somewhat boring for the subjects. This boredom may have directly led to no difference in arousal (“engagement” and “excitement”) in both behaviors. There was also a small difference in “frustration,” which represents a low valence emotion. Although no significant difference was achieved, the posttest results regarding the “frustration” in the walking group were always higher than that of the sitting group when the minute-by-minute dynamic EEG index values were examined. Neale et al.’s study also showed similar results, which indicated that the “frustration” of walking in urban green spaces was higher than that in urban busy areas [39]. First, we believe that the frustration was caused by the fact that the limited experimental space could not meet the psychological demand for more walking space [62]. Second, the frustration may have been related to external disturbances from which the participants could not be completely isolated, such as urban noise.

In addition, previous research has shown that plant landscapes with moderate biological diversity are best at evoking positive emotions, preferences, and feelings of importance [8]. Other researchers have suggested that high biodiversity and dense plant landscapes are better for health [33, 63], such as higher concentration, lower stress, and a better mental state. Chiang et al. concluded that relaxation under high biodiversity conditions actually corresponds to low arousal [33]. Although biodiversity is not the target variable of this study, only bamboo and lawn were used in this study, which is obviously a green space with low biodiversity. The six emotional parameters showed different results among different behaviors, and some of them also showed low arousal emotional states. We do not believe that this finding contradicts previous studies, as the relationship between biodiversity and physiology and psychology has not been determined. We suggest there may be a connection between different behaviors and biodiversity.

Limitations and Future Research

There are numerous limitations in this study. First, the only variable on which this study focuses is behavior. We speculate that the size of the green space, plant biodiversity, and number of individuals present will also have certain impacts on behavior and emotion. In the future, we will consider setting up crossover experiments with multiple variables, such as different behaviors and different areas per capita. Second, in this experiment, a horizontal comparison of single variables and short-term effects was the primary focus. In the future, long-term experiments or secondary validation experiments will be conducted to verify the recovered performance. Third, we focused on neural emotional indicators in this experiment, but the algorithm and its relationship to α, β, and other brain waves are unknown. Therefore, other psychophysiological indicators, such as blood pressure, a brainwave index, and psychological questionnaires, are also worthy of study. The correlations among neural emotional indicators and other indictors could be used to further explain urban green space behavior.

Application

On the one hand, this study provides a reference for the planning and design of urban green space. Individuals under high pressure in the city are concentrated in office buildings, factories, schools, and other areas. Urban green space should be arranged around these areas to effectively guide individuals into these green spaces. The balance between the amount of green space and population density should be considered to ensure that the available green space can serve more individuals. Walking and staying spaces should be arranged to meet different outdoor health needs. Walking paths in the green space should be surrounded by more plants, which provides an environment more conducive to the relaxation and decompression of stressed individuals. On the other hand, the findings could provide health guidance to stressed individuals in cities, especially in densely populated areas. Individuals can recognize the value of urban green space and consciously walk or sit for stress reduction or attention restoration.

Conclusion

This study focused on the emotional activities caused by walking and sitting in urban green spaces. A dynamic EEG measurement was used, and we obtained six neural emotional parameters. We analyzed intergroup differences between the two groups by ANCOVA and dynamic values and obtained significant results: the values of "valence" and "meditation" in the walking group were higher than those in the sitting group, and the value of "focus" in the sitting group was higher than that in the walking group. The other parameters did not display significant results between the two groups. We discussed the results, combined with the theories of ART, SRT, and outdoor space, and suggested that short-term walking in urban green spaces is more conducive to reducing stress and that short-term sitting is more conducive to restoring attention. These findings provide a valuable reference for urban green space planning and design, as well as health guidance for urban populations.

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