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Study on the Impact of Campus Green Space Biodiversity on the Physical and Mental Health of College Students

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Abstract

Green landscapes in colleges and universities have important effects on the physiological and psychological indicators of college students. Based on virtual reality technology and environmental emotion perception measurement technology, the article constructs three biodiversity virtual reality landscape green areas and measures the changes of physiological indexes (brain waves) and psychological indexes (anxiety level) during 68 subjects' experience of virtual reality scenes to investigate the effects of different biodiversity green areas landscape on human physiological and psychological indexes. The results showed that: The biodiversity of the green space landscape had significant effects on physiological and psychological recovery, in which the high biodiversity environment had better recovery effects than the low biodiversity; however, students were more focused in the low biodiversity environment; the effects of the virtual green space landscape on physiological and psychological were consistent with the real environment.

Keywords

Campus Green Space, Biodiversity, Environmental Perception, Physical and Mental Health, Restorative Environments, Virtual Reality, Electroencephalography

1. Introduction

Mental fatigue and stress-related mental disorders, depression and anxiety are known to be associated with risk factors for personal well-being and positive well-being (Martínez-Soto et al., 2014; Pearson & Craig, 2014; Gao et al., 2019a).

One in four people suffer from a mental disorder in one of their lives (Martínez-Soto et al., 2014). Researchers related to environmental health suggest that a green environment may reduce the level of stress-related mental disorders and thus enhance positive mental health (Pearson & Craig, 2014; Bratman et al., 2012; Wood et al., 2017; Dzhambov et al., 2019; Wang et al., 2019a; Wendelboe-Nelson et al., 2019; Birch et al., 2020; Loder et al., 2020; Marzukhi et al., 2020; Dzhambov et al., 2019). For example, Dzhambov et al. (Dzhambov et al., 2019) have shown that green spaces can provide restorative experiences and promote better psychological well-being.

In the relationship between human health and the environment, the positive impact of green space on the development of positive mental health is considered to be the experience of psychological recovery (Memari et al., 2017). Psychological recovery is the direct effect of contact with green space on promoting positive mental health outcomes (Francis et al., 2012; Subiza-Pérez et al., 2020). It refers to the renewal of "directed attention skills" that have been depleted through continued use in daily life, "physiological changes from tension and stress to relaxation," and "positive mental health outcomes" and "positive mood changes" (Korpela et al., 2008). Through a review of the literature, much attention has been paid to investigating the recovery experiences of green spaces in mental health promotion (Martínez-Soto et al., 2014, Dzhambov et al., 2019, Dzhambov et al., 2019). The importance of green spaces in improving mental health status relates to "promotion of subjective well-being," "prevention of mental disorders," and "treatment and rehabilitation of patients with mental disorders" (Martínez-Soto et al., 2014).

Many of the methods used by researchers to measure the mental health benefits of green space involve multidimensional definitions of health outcomes, such as cognitive and emotional recovery (Martínez-Soto et al., 2014), attention recovery (Felsten, 2009), cognitive functioning (Pearson & Craig, 2014), and emotional well-being (Korpela et al., 2014; Marselle et al., 2016). According to the World Health Organization (WHO), health is not the absence of disease, but a state of physical, mental, and social well-being (Gao et al., 2019a). Social and environmental stressors, ongoing stress, mental fatigue, and negative emotional states can lead to harmful diseases such as heart disease, type II diabetes, and mental illness (Martínez-Soto et al., 2014, Memari et al., 2017), especially if people neglect to recharge their psycho-physical and emotional resources. Therefore, in order to effectively cope with the mental disorders required for everyday life, people need to regularly restore impaired resources from a negative state to a pristine state.

Themes related to mental health promotion among college students have also demonstrated the restorative potential of outdoor campus green spaces in terms of students' psychological recovery and positive mental health development (Liu et al., 2018; Gulwadi et al., 2019). According to developmental psychology, college students (usually aged 18 - 25 years) are in the middle and late adolescence and early adulthood, the transition stage from adolescence to adulthood (Feld-

man, 2010). During this period, college students need to complete a number of tasks such as independence from their families of origin, establishing goals for self-development, establishing intimate relationships, and rapidly adapting to a series of changes in learning style, lifestyle, developmental goals, their roles, and interpersonal relationships, in order to prepare for their transition to the adult world. The sudden changes and stresses are very likely to induce low self-esteem, anxiety, anger, depression, jealousy and other adverse emotions, which greatly damage the mental health and physical health of college students (Fan & Mao, 2016). In recent years, the mental health of college students has received widespread attention from society and academia (He & Luo, 2015). To enhance the mental health of college students, the importance of outdoor campus green spaces has been recognized as a potentially restorative environment that contributes to their psychological recovery (Adams et al., 2008; Van den Bogerd et al., 2020), concentration recovery (Lu & Fu, 2019), and mental fatigue recovery (Liu et al., 2018). As many studies have shown, it is possible to enjoy psychologically restorative experiences and mental health benefits in an outdoor environment.

How to create a healthy campus environment has become a research hot spot. Established campus landscape-related studies have focused on ecological environment, aesthetic quality, activity behavior, and landscape preferences (Hossini et al., 2015; Chen & Yu, 2011), and a complete system has not yet been formed for campus healthy landscape construction. The natural degree of spatial environment is positively correlated with human physical and mental health (Maas et al., 2006), and some scholars have studied the differential impact of classroom window view greening level (Matsuoka, 2010; Li & Sullivan, 2016) and campus green space environment characteristics (Wang et al., 2020) on health, but there are fewer studies on the relationship between biodiversity and health. Regarding research methods, virtual reality scenes can effectively control research variables, reduce interference, and provide realistic immersive environmental experiences (Chamilothori et al., 2018), while virtual nature scenes have positive effects on subjects' physiology and psychology (Giovanna et al., 2017), and the effects are similar to those of real natural environments (Browning et al., 2019).

In view of this, this paper selects college green space landscape as the research object and constructs virtual reality scenes of different complexity, aiming to explore the effects of different biodiversity green space landscapes on the physiological and psychological recovery of college students. In order to complement the theory and practice of healthy campus landscape and promote the creation and improvement of restorative spaces on campus.

2. Materials and Methods

2.1. Experimental Procedure

In this study, green areas with typical vegetation structure in campus green areas were selected through field research, and the characteristics were summarized and modeled in the modeling software and imported into VR equipment. The

subjects' EEG indicators were monitored and recorded during the VR viewing process, and they were asked to fill in the S-AI scale before and after the viewing. The data collected from the experiment were then imported into SPSS software for relevant data analysis (Figure 1).

2.2. Experimental Sample Setting

The experiment selects the atrium of the university teaching building as the blueprint for virtual reality scene model design, applies these landscape elements for virtual reality scene design according to the complexity of the green landscape, and measures the complexity of the scene according to the biodiversity and quantity in the scene, i.e. the more biodiversity, the higher the complexity of the scene. In this study, three scenes are designed as experimental samples. The three levels of biodiversity are formed into three different virtual scenes of low, medium and high.

2.3. Volunteer Recruitment

The inclusion criteria for participants were 1) undergraduate and master's degree students aged 18 - 28 years old; 2) Subjects were required to be in good health, not taking any recent medications, not suffering from chronic diseases, not abusing alcohol and not smoking; and 3) no strong discomfort with the VR experience. The final sample consisted of 68 participants who completed the full set of experiments and assessments.

2.4. Experimental Instruments

2.4.1. Psychological Signals

A brief version of the State-Trait Anxiety Inventory (S-AI) was used to measure anxiety levels. The brief version of the S-AI consists of six questions: calm, nervous, relaxed, disturbed, contended, and annoyed, half of which describe positive Half of the questions describe positive emotions and half describe negative emotions, and are designed to assess the subject's immediate or recent experience

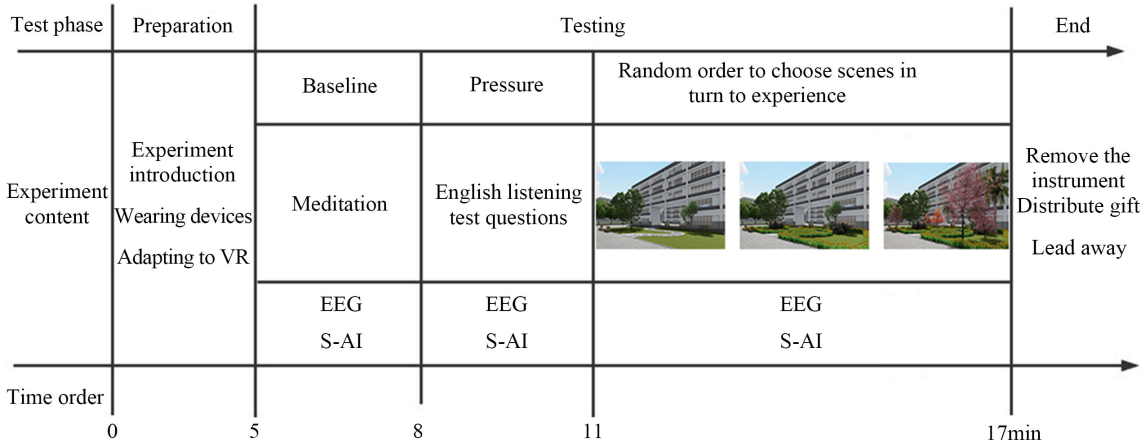

Figure 1. Experimental design and data gathering organization.

or feelings at a particular time. The short version of the S-AI has been tested and validated to be as effective as the full version of the S-AI with 20 questions. The negative correlations between nervous, disturbed and annoyed and emotional recovery performance were inverse scores, with high scores reflecting high levels of anxiety in the subjects.

2.4.2. Physiological Signals

One of the most commercially successful EEG mobile devices is the Emotiv Epoc, a non-invasive real-time brain acquisition device. EEG consists of 16 sensors (including two reference potentials) with a built-in Bluetooth module that transmits EEG signals to a computer without any connection cable. It is ergonomic, wireless and low cost compared to other mobile EEG systems. It has also shown ways to measure real-time emotions such as stress, excitement and boredom, which can have more complex emotional interpretations. The raw EEG signals is translated and classified into ten different emotional states. Boredom, Attention, Cognitive Stress, Engagement, Excitement, Focus, Interest, Relaxation and Stress were selected as the evaluation indicators of the restoration potential of campus green space landscape (**Figure 2**).

3. Results

3.1. Psychological Signals

Campus green space landscape biodiversity changes had an effect on calm, nervous, relaxed, disturbed, and contented changes, but unfortunately, we did not find a significant effect of biodiversity on annoyed. As biodiversity increased, relaxed and contented in mood increased, and calm, nervous and disturbed decreased. However, when biodiversity reached a certain level, the effect on mood was limited.

1) Calm:

The analysis showed that biodiversity ($F = 5.016$, $p = 0.002 < 0.05$) could significantly affect calm in this experiment, and it could explain 39.5% of the change in calm, and biodiversity produced a negative correlation with calm. This indicates that reducing biodiversity within the campus green space can significantly make people in the environment feel calm (**Figure 3**).

2) Nervous:

The analysis showed that biodiversity ($F = 12.407$, $p = 0.000 < 0.05$) could significantly affect nervous in this experiment, it could explain 61.8% of the changes in nervous, and biodiversity produced a negative correlation with nervous. Post hoc comparisons revealed that subjects' nervousness was significantly higher when biodiversity within the campus green landscape was single than when biodiversity was high and medium, and nervousness was lowest when biodiversity was medium. This indicates that campus green space with high biodiversity and a large number of people can significantly make people in the environment feel nervous (**Figure 4**).

Figure 2. Emotiv Epoc portable EEG instrument.

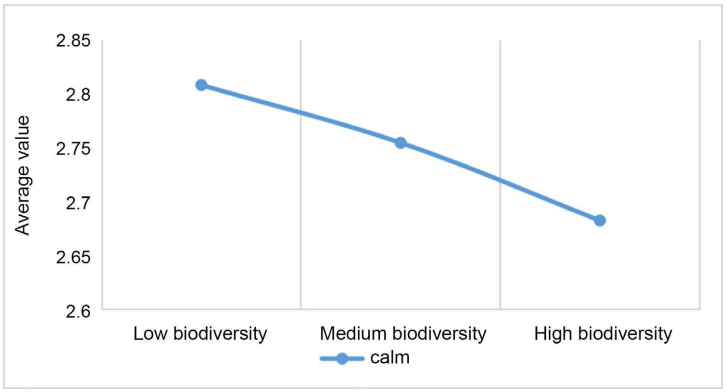

Figure 3. Calm mean values at different biodiversities.

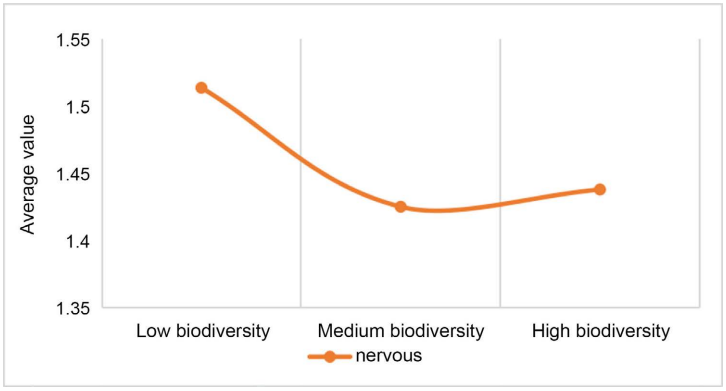

Figure 4. Nervous mean values at different biodiversities.

3) Disturbed:

The analysis showed that biodiversity (F = 3.830, $p = 0.023 < 0.05$) could significantly affect disturbed in this experiment and it could explain 33.1% of the variation in disturbed. Biodiversity was negatively correlated with disturbed. Post hoc comparisons revealed that subjects' disturbed was significantly higher when biodiversity within the campus green landscape was single than when biodiversity was high and medium, and disturbed was lowest when biodiversity was medium. This indicates that all campus green space landscapes with high biodiversity significantly disturbed people in the environment, and when the biodi-

versity within the space is medium, people in the space have the lowest disturbed values (Figure 5).

4) Relaxed:

The analysis results showed that biodiversity (F = 15.543, p = 0.000 < 0.05) could significantly affect relaxed in this experiment, and it could explain 67.0% of the variation in relaxed. Biodiversity produced a positive correlation with relaxed. Post hoc comparisons revealed that subjects' relaxed was significantly higher when biodiversity within the campus green space landscape was high than when biodiversity was single and medium.

This suggests that increasing the biodiversity within the campus green space can significantly make people in the environment feel relaxed (Figure 6).

5) contented:

The results of the analysis showed that biodiversity (F = 6.079, p = 0.007 < 0.05) could significantly affect contented in this experiment and they could explain 33.6% of the variation in contented. Biodiversity produced a positive correlation with contented. Post hoc comparisons revealed that subjects' contented was significantly higher when biodiversity was high and medium within the campus green landscape than when biodiversity was single, and the difference between medium or high biodiversity on contented was not significant. This suggests that either high or medium biodiversity significantly contented people in the environment (Figure 7).

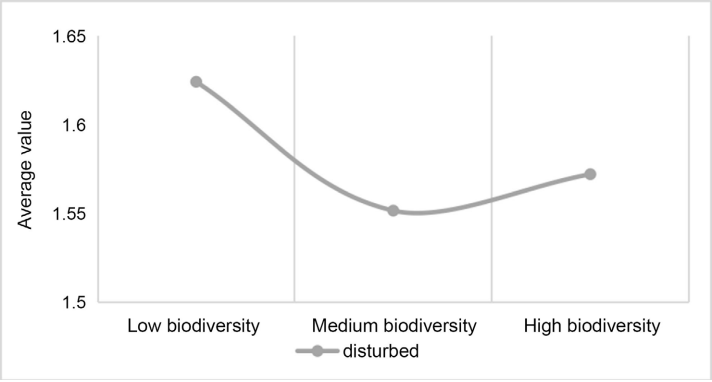

Figure 5. Disturbed mean values at different biodiversities.

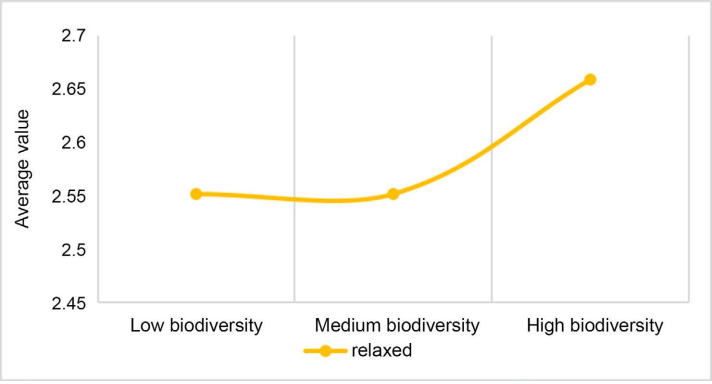

Figure 6. Relaxed mean values at different biodiversities.

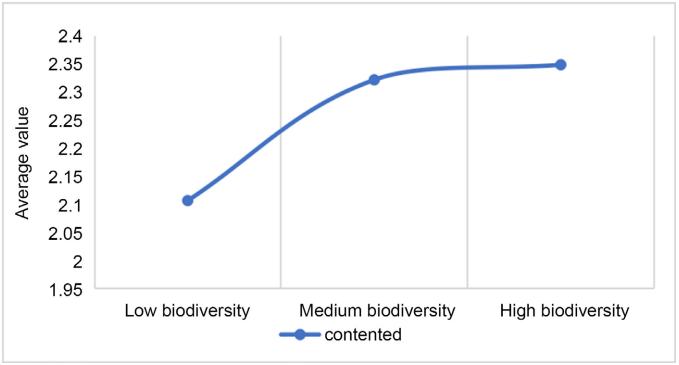

Figure 7. Contented mean values at different biodiversities.

3.2. Physiological Signals

The recovery performance of biodiversity on physiological signals was significant, and it significantly affected Boredom, Cognitive Stress, Interest and Relaxation. As biodiversity increased, the EEG signals of Cognitive Stress, Interest and Relaxation increased and Boredom decreased. Unfortunately, we did not find significant effects of biodiversity on Attention, Visual Attention, Excitement, Engagement, Focus, and Stress. However, when biodiversity reached a certain level, the effect on EEG was limited.

1) Boredom:

The analysis showed that biodiversity ($F = 6.107$, $p = 0.003 < 0.05$) could significantly affect Boredom in this experiment, and they could explain 44.3% of the changes in Boredom. Biodiversity produced a negative correlation with Boredom. Post hoc comparisons revealed that subjects' Boredom was significantly higher when biodiversity within the campus green space landscape was single than when biodiversity was complex and moderate. This suggests that reducing biodiversity within the campus green space can significantly increase the Boredom of people in the environment (**Figure 8**).

2) Cognitive Stress:

The analysis results showed that biodiversity ($F = 3.814$, $p = 0.024 < 0.05$) could significantly affect Cognitive Stress in this experiment, and they could explain 33.2% of the change in Cognitive Stress. Biodiversity and Cognitive Stress produced positive biodiversity was positively correlated with Cognitive Stress. Post hoc comparisons revealed that subjects' Cognitive Stress was significantly higher when the biodiversity within the campus green landscape was complex and moderate than when the biodiversity was single. This indicates that the higher the biodiversity of the campus green landscape, the higher the Cognitive Stress of the subjects (**Figure 9**).

3) Interest:

The analysis showed that biodiversity ($F = 15.484$, $p = 0.003 < 0.05$) significantly influenced Interest in this experiment, and it explained 66.9% of the variation in Interest. Biodiversity produced a positive correlation with Interest. Post hoc comparisons revealed that subjects' Interest was significantly higher when biodiversity within the campus green space landscape was complex than when

biodiversity was complex and moderate. This suggests that increasing the biodiversity within the campus green space can significantly increase the Interest of people in the environment (Figure 10).

4) Relaxation:

The results of the analysis showed that biodiversity, a factor reflecting complexity ($F = 4.777$, $p = 0.040 < 0.05$), could significantly affect Relaxation in this experiment, and it could explain 29.8% of the changes in Relaxation, and biodiversity produced a positive correlation with Relaxation. Post hoc comparisons revealed that Relaxation increased with the biodiversity within the campus green space landscape. This suggests that campus green space landscapes with complex biodiversity resulted in the highest Relaxation for the subjects (Figure 11).

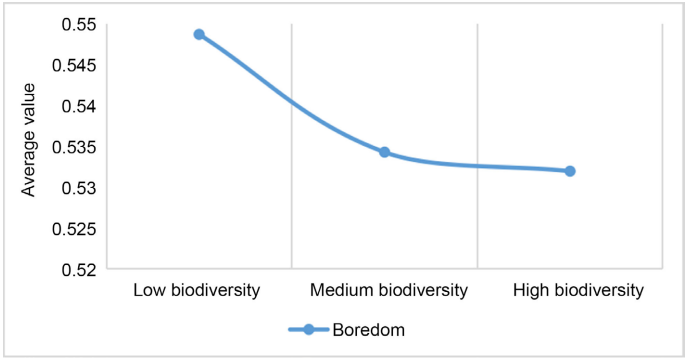

Figure 8. Boredom means values at different biodiversities.

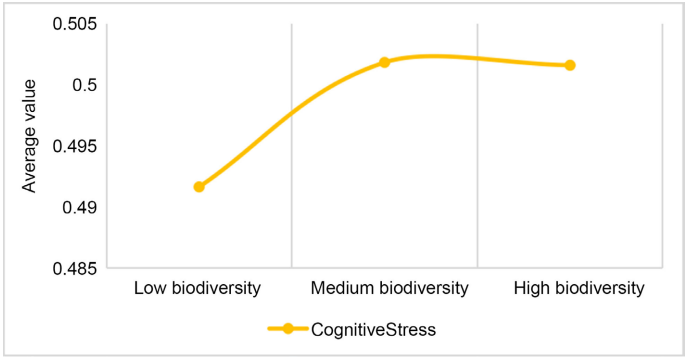

Figure 9. Cognitive Stress means values at different biodiversities.

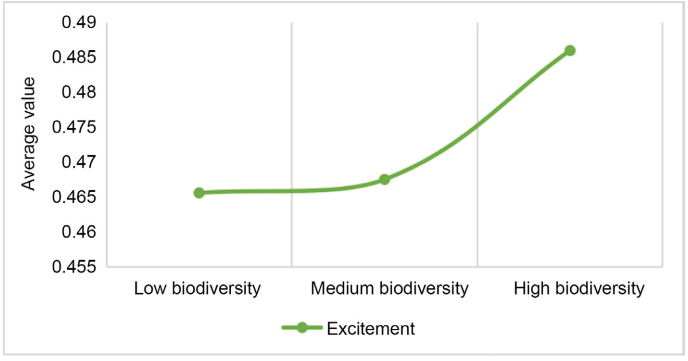

Figure 10. Excitement means values at different biodiversities.

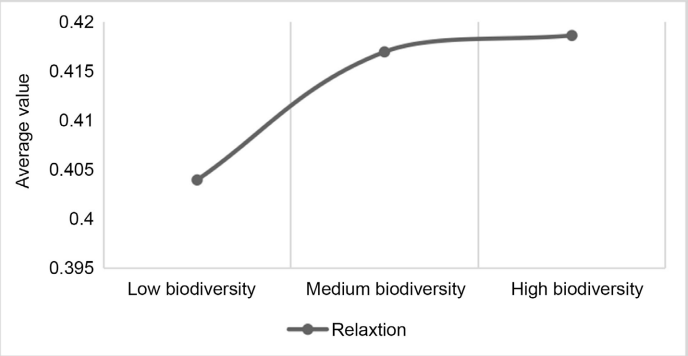

Figure 11. Relaxtion means values at different biodiversities.

4. Discussion

4.1. Comparison of Physical and Psychological Recovery before and after Visual Stimulation of VR Landscapes

This study compares the different complexity of campus green space before and after the different psychological and physiological recovery. Using virtual reality equipment, it is found that the recovery score of the respondents decreases after viewing three different biological diversity green space virtual environments, which means that all three different levels of biological diversity campus green space landscape can produce some benefits of psychological recovery.

Similar to the results of this study, Gao et al. (Gao et al., 2019b) also found that the change in EEG was not significant when looking at a blank wall in the open-eye state compared to perceiving the landscape space using VR, but instead, the closed-eye state produced a significant change in EEG. A possible explanation for this result is that the staff asked the participants to be as relaxed as possible during the experiment and asked each participant to be calm for 2 minutes before the start of the experiment in order to minimize the differences in baseline levels between individuals, during which time the participants were relaxed enough and their heart rate was calm, so that the EEG and heart rate variability did not change significantly before and after the visual stimulation of the VR landscape (Kjellgren & Buhrkall, 2010). There was no significant change in EEG and heart rate variability before and after the visual stimulation of the VR landscape (Kjellgren & Buhrkall, 2010). Therefore, studies of brain wave changes should pay attention to the control of pre-experimental baseline levels, and the experimental procedure of pressure application can be increased to more effectively study the role of landscape space on heart rate variability and brain wave effects. Another possible explanation is that the photographs of the experimental site used in this study were taken from the campus green space, which can be seen everywhere in students' daily life, and the subjects were more familiar with such scenes. According to the neurobiological theory, it is difficult for people to feel novelty in familiar and usual environments, and the lack of novel stimuli makes it difficult for subjects' brains to produce chemicals such as dopamine and endorphins that can awaken positive emotions (Russell, 1980), so

some indicators did not change significantly before and after viewing the scenes. However, from the overall findings, the emotional signals of Calm, Tense, Relaxed, Disturbed, and Satisfied; the physiological signals of Heart Rate and Blood Pressure; the EEG signals of Boredom, Attention, Visual Attention, Cognitive Stress, Engagement, Excitement Interest, Relaxation, and Stress before and after visual stimulation in different sites still show that even a brief experience of viewing a natural environment in a VR environment can still bring out the restorative benefits of green space, relieve people's psychological stress, and promote physiological arousal. In the future, photos of green space environments in urban parks can be imported into VR devices for daily home relaxation activities for patients with hypertension and other conditions that make it difficult to leave home, thus promoting physical health and relieving home anxiety.

4.2. Restorative Differences in Campus Green Space Landscape by Biodiversity

The restorative performance of biodiversity on mood was the most significant, which significantly affected calmness, tension, relaxation, irritability, and contentment. As biodiversity increased, the mean values of relaxation and contentment in mood increased, and the mean values of calmness, tension and irritability decreased. Biodiversity also significantly affected the restorative performance of EEG, which significantly affected the mean values of Boredom, Cognitive Stress, Excitement and Interest. As biodiversity increased, the mean values of Cognitive Stress, Excitement and Interest in the EEG signal increased and the mean value of Boredom decreased. Under normal conditions, the human body becomes more effective in recovery as the biodiversity in the environment increases, which is consistent with the findings of Ronghua Wang, Bin Jiang et al. (Wang et al., 2019b; Jiang et al., 2014; Jamie Tratalos et al., 2007). However, it is noteworthy that Gatersleben et al. conducted a similar investigation on a national forest park in the United Kingdom, and the conclusion was opposite to the results of the present experiment, which may be due to the fact that the complex wilderness environment of biodiversity drives people to focus their attention in order to be prepared to escape in time to meet the danger. The inconsistency between the results of this experiment and the above-mentioned studies may be due to the differences in the survey samples. Compared with the National Forest Park, the campus green space landscape has a clear structure and a neat sequence of green spaces that do not generate negative emotions such as tension and worry. This may be due to the fact that the complex wilderness environment of biodiversity drives people to focus their attention in order to be prepared to escape in time to meet the danger. The inconsistency between the results of this experiment and the above-mentioned studies may be due to the differences in the survey samples. Compared with the National Forest Park, the campus green space landscape has a clear structure and a neat sequence of green spaces that do not generate negative emotions such as tension and worry (Gatersleben & Andrews, 2013).

4.3. Time Performance Analysis of the Impact of Campus Green Space Landscape on College Students' Physical and Mental Health

Significant changes in physiological indicators indicated that the subjects' physiological stress was relieved after experiencing the green space landscape. The 47 min experiments on physiological indicators of heart rate, blood pressure, and EEG showed that in the first 5 min of the 36 min recovery process (i.e., the 11th-16th min of the whole process), the stress levels recovered rapidly; the last 21 min were relatively stable, and even in the last 5 - 10 min, the stress levels of individual indicators showed signs of rebound, indicating that it took 3 - 5 min to recover under a certain immediate stress level (i.e., the stress characteristic of the applied stress state). This result is more consistent with the study of (Yin et al., 2018). In addition, none of the physiological index levels returned to baseline levels, suggesting that sympathetic nerves were still active during the 5 min period and that more time may be needed to adjust them. The changes in psychological indicators showed that the subjects showed different degrees of anxiety reduction after experiencing the campus green space landscape.

4.4. Design Suggestions

Through the experiment, it can be seen that the establishment of a highly restorative campus green landscape needs to increase the biodiversity in the environment. It should ensure that there are green spaces on campus that serve to enhance biodiversity, provide ecosystem services, create opportunities for college students to engage with nature, and improve mental health. But it is necessary to pay attention to the level of vegetation structure, strengthen the maintenance of plant level communities, and pay attention to the level of medium and long term scenes to avoid that too dense plants or other shading will not affect the landscape line and damage the restoration effect of green landscape. When the scale of the site is limited, small water features can also be considered to create. At the same time, biodiversity high scene will make people's attention drop and increase people's cognitive pressure, so in the landscape design of the campus, involving learning, class space, should not set rich plants and animals.

4.5. Strengths and Limitations

Our study adds to the understanding of the relationship between environment and health. In this study, we used virtual reality technology combined with various physiological and psychological indicators (S-AI scale, EEG) in a controlled experiment to explore its relationship with human physiological and psychological indicators using the complexity of the campus landscape to provide a new perspective on cognitive health. In this paper, three virtual green landscapes are constructed, which effectively control the gradient changes of research variables, reduce the interference factors in the experimental process, make the research experiments more scientific and reasonable, and modern virtual reality scenes replace the traditional real scenes to provide environmental conditions for rele-

vant research.

However, there are still many urgent problems in this study. For example, the screened subjects can enrich the representativeness of the sample, but cannot avoid the differences in individual work experience and spatial preferences; factors such as temperature and noise of the field experiment can interfere with the recovery performance; the way of measuring physiological signals such as blood pressure still lacks precision; this study examines the changes of psychological and physiological responses under different types of environments in a short period of time, and due to the inconsistency of the time of psychological and physiological changes The present study examined changes in psychological and physiological responses in different environmental types over a short period of time, and because of the inconsistency in the timing of psychological and physiological changes, the role of environmental recovery can be further explored in the future over a longer time frame. It has been demonstrated that sounds and smells in the environment can also affect people's preference levels and restorative experiences. In this study, although VR devices have been shown to function as a substitute for real scenes, in order to obtain a more realistic environmental experience, other sensory experiences such as smell, hearing, and touch can be added together with visual stimuli in the future to explore the effects of multi-sensory experiences on the restorative effects of green space environments.

5. Conclusion

1) Green landscape can relieve the physical and psychological stress of college students and promote physical and mental health.

2) The change of biodiversity is positively correlated with relaxed, contented in psychological signal, cognitive stress, interest, and relaxation in physiological signal; it is positively correlated with clam, nervous, disturbed in psychological signal, and boredom in the physiological signal is negatively correlated.

3) Over time, the virtual reality environment led to a gradual decrease in its effect on the EEG. In this experiment, the recovery benefit of campus green landscape biodiversity on EEG was the most significant in the first 5 min after the end of pressurization, and the recovery benefit effect decreased significantly in the last 5 - 10 min or so of the experiment, and even showed signs of rebound. Although VR devices have been shown to replace real scenes, whether the temporal performance of VR scenes on EEG effects is different from that of real environments which can be studied in the future.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

Adams, T. B., Wharton, C. M., Quilter, L., & Hirsch, T. (2008). The Association between Mental Health and Acute Infectious Illness among a National Sample of 18- to 24-Year-Old College Students. *Journal of American College Health, 56,* 657-664. https://doi.org/10.3200/JACH.56.6.657-664

Birch, J., Rishbeth, C., & Payne, S. R. (2020). Nature Doesn't Judge You—How Urban Nature Supports Young People's Mental Health and Wellbeing in a Diverse UK City. *Health & Place, 62,* Article ID: 102296. https://doi.org/10.1016/j.healthplace.2020.102296

Bratman, G. N., Hamilton, J. P., & Daily, G. C. (2012). The Impacts of Nature Experience on Human Cognitive Function and Mental Health. *Annals of the New York Academy of Sciences, 1249,* 118-136. https://doi.org/10.1111/j.1749-6632.2011.06400.x

Browning, M. H. E. M., Mimnaugh, K. J., Van Riper, C. J., Laurent, H. K., & LaValle, S. M. (2019). Can Simulated Nature Support Health? Comparing Short, Single-Doses of 360-Degree Nature Videos in Virtual Reality with the Outdoors. *Frontiers in Psychology, 10,* Article 2667. https://doi.org/10.3389/fpsyg.2019.02667

Chamilothori, K., Wienold, J., & Andersen, M. (2018). Adequacy of Immersive Virtual Reality for the Perception of Daylit Spaces: Comparison of Real and Virtual Environments. *LEUKOS, 15,* 203-226. https://doi.org/10.1080/15502724.2017.1404918

Chen, X., & Yu, J. H. (2011). Exploration on Design Strategy of Campus Landscape from Environmental Psychology. *Advanced Materials Research, 243-249,* 6461-6464. https://doi.org/10.4028/www.scientific.net/AMR.243-249.6461

Dzhambov, A. M., Hartig, T., Tilov, B., Atanasova, V., Makakova, D. R., & Dimitrova, D. D. (2019). Residential Greenspace Is Associated with Mental Health via Intertwined Capacity-Building and Capacity-Restoring Pathways. *Environmental Research, 178,* Article ID: 108708. https://doi.org/10.1016/j.envres.2019.108708

Fan, Z. X., & Mao, T. T. (2016). *Exploration of College Students' Psychological Problems and Countermeasures in New Period* (pp. 22-65). China Book Press.

Feldman, R. S. (2010). *Development across the Life Span* (6th ed., pp. 486-559). Prentice Hall.

Felsten, G. (2009). Where to Take a Study Break on the College Campus: An Attention Restoration Theory Perspective. *Journal of Environmental Psychology, 29,* 160-167. https://doi.org/10.1016/j.jenvp.2008.11.006

Francis, J., Wood, L. J., Knuiman, M., & Giles-Corti, B. (2012). Quality or Quantity? Exploring the Relationship between Public Open Space Attributes and Mental Health in Perth, Western Australia. *Social Science & Medicine, 74,* 1570-1577. https://doi.org/10.1016/j.socscimed.2012.01.032

Gao, T., Song, R., Zhu, L., & Qiu, L. (2019a). What Characteristics of Urban Green Spaces and Recreational Activities Do Self-Reported Stressed Individuals Like? A Case Study of Baoji, China. Int J Environ Res Pub Health. *International Journal of Environmental Research and Public Health, 16,* Article No. 1348. https://doi.org/10.3390/ijerph16081348

Gao, T., Zhang, T., Zhu, L., Gao, Y., & Qiu, L. (2019b). Exploring Psychophysiological Restoration and Individual Preference in the Different Environments Based on Virtual Reality. *International Journal of Environmental Research and Public Health, 16,* Article No. 3102. https://doi.org/10.3390/ijerph16173102

Gatersleben, B., & Andrews, M. (2013). When Walking in Nature is Not Restorative—The Role of Prospect and Refuge. *Health & Place, 20,* 91-101.

https://doi.org/10.1016/j.healthplace.2013.01.001

Giovanna, C., Sigbjǫm, S., Fagerheim, K. A. et al. (2017). Experiencing Nature through Immersive Virtual Environments: Environmental Perceptions, Physical Engagement, and Affective Responses during a Simulated Nature Walk. *Frontiers in Psychology, 8,* Article 2321. https://doi.org/10.3389/fpsyg.2017.02321

Gulwadi, G. B., Mishchenko, E. D., Hallowell, G., Alves, S., & Kennedy, M. (2019). The Restorative Potential of a University Campus: Objective Greenness and Student Perceptions in Turkey and the United States. *Landscape and Urban Planning, 187,* 36-46. https://doi.org/10.1016/j.landurbplan.2019.03.003

He, H., & Luo, Y. (2015). Analysis on Depression Status and Influence Factors of University Students in Beijing. *Modern Preventive Medicine, No. 7,* 1261-1264. (In Chinese)

Hossini, S. B., Azemati, S., Elyasi, N., & Mozaffar, F. (2015). The Effect of the Vitality Level of University Campuses on Increasing Social Interactions and Makin. *Procedia-Social and Behavioral Sciences, 170,* 225-233. https://doi.org/10.1016/j.sbspro.2015.01.032

Jiang, B., Chang, C.-Y., & Sullivan, W. C. (2014). A Dose of Nature: Tree Cover, Stress Reduction, and Gender Differences. *Landscape and Urban Planning, 132,* 26-36. https://doi.org/10.1016/j.landurbplan.2014.08.005

Kjellgren, A., & Buhrkall, H. (2010). A Comparison of the Restorative Effect of a Natural Environment with That of a Simulated Natural Environment. *Journal of Environmental Psychology, 30,* 464-472. https://doi.org/10.1016/j.jenvp.2010.01.011

Korpela, K. M., Ylén, M., Tyrväinen, L., & Silvennoinen, H. (2008). Determinants of Restorative Experiences in Everyday Favorite Places. *Health & Place, 14,* 636-652. https://doi.org/10.1016/j.healthplace.2007.10.008

Korpela, K., Borodulin, K., Neuvonen, M., Paronen, O., & Tyrväinen, L. (2014). Analyzing the Mediators between Nature-Based Outdoor Recreation and Emotional Well-Being. *Journal of Environmental Psychology, 37,* 1-7. https://doi.org/10.1016/j.jenvp.2013.11.003

Li, D. Y., & Sullivan, W. C. (2016). Impact of Views to School Landscapes on Recovery from Stress and Mental Fatigue. *Landscape and Urban Planning, 148,* 149-158. https://doi.org/10.1016/j.landurbplan.2015.12.015

Liu, Q., Zhang, Y., Lin, Y., You, D., Zhang, W., Huang, Q. et al. (2018). The Relationship between Self-Rated Naturalness of University Green Space and Students' Restoration and Health. *Urban Forestry & Urban Greening, 34,* 259-268. https://doi.org/10.1016/j.ufug.2018.07.008

Loder, A. K. F., Schwerdtfeger, A. R., & van Poppel, M. N. (2020). Perceived Greenness at Home and at University Are Independently Associated with Mental Health. *BMC Public Health, 20,* Article No. 802. https://doi.org/10.1186/s12889-020-8412-7

Lu, M., & Fu, J. (2019). Attention Restoration Space on a University Campus: Exploring Restorative Campus Design Based on Environmental Preferences of Students. *International Journal of Environmental Research and Public Health, 16,* Article No. 2629. https://doi.org/10.3390/ijerph16142629

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,* 587-592. https://doi.org/10.1136/jech.2005.043125

Marselle, M. R., Irvine, K. N., Lorenzo-Arribas, A., & Warber, S. L. (2016). Does Perceived Restorativeness Mediate the Effects of Perceived Biodiversity and Perceived Naturalness on Emotional Well-Being Following Group Walks in Nature? *Journal of Environmental Psychology, 46,* 217-232. https://doi.org/10.1016/j.jenvp.2016.04.008

Martínez-Soto, J., Lena, M. M. L., & Córdova, A. (2014). Psychological Restoration and Urban Nature: Some Mental Health Implications. *Salud Mental, 37,* 211-218.

Marzukhi, M. A., Ghazali, N. M., Leh, O. L. H., & Yakob, H. (2020). A Bidirectional Associations between Urban Physical Environment and Mental Health: A Theoretical Framework. *Environment-Behaviour Proceedings Journal, 5,* 167-173. https://doi.org/10.21834/e-bpj.v5i13.2048

Matsuoka, R. H. (2010). Student Performance and High School Landscapes: Examining the Links. *Landscape and Urban Planning, 97,* 273-282. https://doi.org/10.1016/j.landurbplan.2010.06.011

Memari, S., Pazhouhanfar, M., & Nourtaghani, A. (2017). Relationship between Perceived Sensory Dimensions and Stress Restoration in Care Settings. *Urban Forestry & Urban Greening, 26,* 104-113. https://doi.org/10.1016/j.ufug.2017.06.003

Pearson, D. G., & Craig, T. (2014). The Great Outdoors? Exploring the Mental Health Benefits of Natural Environments. *Frontiers in Psychology, 5,* Article 1178. https://doi.org/10.3389/fpsyg.2014.01178

Russell, J. A. (1980). A Circumplex Model of Affect. *Journal of Personality and Social Psychology, 39,* 1161-1178. https://doi.org/10.1037/h0077714

Subiza-Pérez, M., Vozmediano, L., & San Juan, C. (2020). Green and Blue Settings as Providers of Mental Health Ecosystem Services: Comparing Urban Beaches and Parks and Building a Predictive Model of Psychological Restoration. *Landscape and Urban Planning, 204,* Article ID: 103926. https://doi.org/10.1016/j.landurbplan.2020.103926

Tratalos, J., Fuller, R. A., Warren, P. H., Davies, R. G., & Gaston, K. J. (2007). Urban form, Biodiversity Potential and Ecosystem Services. *Landscape and Urban Planning, 83,* 308-317. https://doi.org/10.1016/j.landurbplan.2007.05.003

Van den Bogerd, N., Dijkstra, S. C., Koole, S. L., Seidell, J. C., de Vries, R., & Maas, J. (2020). Nature in the Indoor and Outdoor Study Environment and Secondary and Tertiary Education Students' Well-Being, Academic Outcomes, and Possible Mediating Pathways: A Systematic Review with Recommendations for Science and Practice. *Health & Place, 66,* Article ID: 102403. https://doi.org/10.1016/j.healthplace.2020.102403

Wang, R. H., Zhao, J. W., Meitner, M. J., Hu, Y., & Xu, X. L. (2019a). Characteristics of Urban Green Spaces in Relation to Aesthetic Preference and Stress Recovery. *Urban Forestry & Urban Greening, 41,* 6-13. https://doi.org/10.1016/j.ufug.2019.03.005

Wang, R., Helbich, M., Yao, Y., Zhang, J., Liu, P., Yuan, Y. et al. (2019b). Urban Greenery and Mental Wellbeing in Adults: Cross-Sectional Mediation Analyses on Multiple Pathways across Different Greenery Measures. *Environmental Research, 176,* Article ID: 108535. https://doi.org/10.1016/j.envres.2019.108535

Wang, X., Zhang, Y. L., Zhao, R. L. et al. (2020). A Study on the Effects of Four Campus Green Space Landscapes on Physiological and Psychological Indicators of College Students. *China Garden, 36,* 92-97. (In Chinese)

Wendelboe-Nelson, C., Kelly, S., Kennedy, M., & Cherrie, J. W. (2019). A Scoping Review Mapping Research on Green Space and Associated Mental Health Benefits. *International Journal of Environmental Research and Public Health, 16,* Article No. 2081. https://doi.org/10.3390/ijerph16122081

Wood, L., Hooper, P., Foster, S., & Bull, F. (2017). Public Green Spaces and Positive Mental Health – Investigating the Relationship between Access, Quantity and Types of Parks and Mental Wellbeing. *Health & Place, 48,* 63-71. https://doi.org/10.1016/j.healthplace.2017.09.002

Yin, J., Zhu, S. H., Macnaughton, P., Allen, J. G., & Spengler, J. D. (2018). Physiological and Cognitive Performance of Exposure to Biophilic Indoor Environment. *Building and Environment, 132,* 255-262. https://doi.org/10.1016/j.buildenv.2018.01.006