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The Effects of Plant Colors on Alleviating Anxiety in College Students

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Abstract: The mental health issues of college students have received widespread attention in recent years, and improving the campus environment plays a significant role in aiding the mental and physical health of college students. Plant color, as the most intuitively perceivable element of the environment, has a direct impact on individuals' mental and physical health; Therefore, investigating the impact of different colors of plants on the psychological health of university students holds significant importance for providing a theoretical basis for the construction of restorative landscape environments on college campuses. This study utilized online questionnaires and invited participants to view plants of different colors (yellow, red, white, green, and black), assessing their psychological impact through various psychological indices. The results indicated that green plants significantly alleviate feelings of tension, unease, and sorrow; white plants have a notable restorative effect on feelings of tension and unease; yellow plants significantly reduce unease and worry; and black plants have a significant restorative effect on unease. Therefore, in the construction of campus landscapes, it is advisable to plant a large number of green and white plants, complemented by yellow plants, to effectively improve the psychological health of college students.

Keywords: Plant Color, Restorative Landscape, College Student Anxiety, Restoration, Psychological Scale, Green Color Effectiveness

1. Introduction

Human health and lifestyle can be affected by residential environment and space[1-4]. It has been reported by the World Health Organization (WTO) that the urban residential environment is the key influencing factor for the health and happiness of residents[5-7].

In recent years, the global burden of mental disorders has increased, and the incidence of depression in college students is on the rise. According to the Report on National Mental Health Development (2021-2022), in the adult population, young people were at high risk of depression, and the detection rate of depression risk in the 18- to 24-year-old population was as high as 24.1%, which was significantly higher than other age groups[8]. The prevention and improvement of anxiety in college students is urgently needed.

Current studies have illustrated that people are more active and excited in natural environments than in urban or indoor environments[9]. More exposure to the natural environment is correlated with a lower level of anxiety[10]. Plants can not only supply materials but also improve human physiological and

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mental health. Stress responses that reduce physiological indicators such as skin conductivity and heart rate can be generated through the observation of photographic images and real natural scenery[11]. Observing plants in nature can effectively alleviate stress, increase happiness, and improve emotions[12-14], and plants or plant images have been substantiated to improve the lower levels of psychological distress and stress recovery, addressing more health issues[15].

Scholars have investigated that both emotions and color vision are controlled by the right brain, indicating correlations between human emotions and colors[16]. Plant color is an important indicator for the improving effect of the natural environment on the public physical and mental health[17]. Different plant colors can have distinct impacts. For instance, red can bring positive impacts of enthusiasm and liveliness but also easily gives rise to irritability with a feeling of alertness, while blue gives a sense of calmness as well as negative emotions of depression.

Research in environmental psychology has confirmed that certain positive features in the environment can provide restorative experiences for individuals within that environment, including alleviating mental stress, reducing psychological fatigue, and mitigating negative emotions, thus aiding in the recovery of mental and physical health issues. The campus environment, as the green space most accessible to college students on a daily basis, has a beneficial effect on students' mental and physical recovery and promotes social interaction. It is an urgently needed research direction in contemporary campus planning and design. However, most campus landscape designs still focus primarily on form and aesthetic appeal, with insufficient exploration and consideration given to their hidden characteristics, such as the role of campus landscapes in promoting health and enhancing environmental restoration. Furthermore, there is a lack of systematic theoretical and methodological research on the impact of campus plant colors on psychological health. Therefore, studying and testing the quality of campus green landscapes from the perspective of restorative environments is of great importance.

This research aims to explore the impact of different colored plants on the psychological health of college students, providing a theoretical basis for the construction of restorative landscapes on college campuses. It is hoped that the results of this study can be applied to the practical landscape construction of campus environments, to offer a more relaxing and health-improving restorative environment for college students.

2. Literature Review

2.1 Attention Restoration Theory

Attention Restoration Theory (ART) was initially proposed by environmental psychologists Rachel and Stephen Kaplan in the United States. Through experimental research, they revealed why natural environments play a crucial role in affecting attention. ART suggests that people process complex information in life through two types of attention: directed attention and involuntary attention. Life events and problems consume directed attention, and since the capacity for directed attention is limited, prolonged expenditure of this resource can lead to fatigue, resulting in difficulties concentrating or emotional instability, thereby impacting work and life. The Kaplans proposed that to restore directed attention, one simply needs to be in an environment that does not deplete attention. Natural environments meet this criterion by alleviating fatigue through two mechanisms: first, by distancing individuals from life situations that generate negative emotions and consume energy, and second, by inducing involuntary attention that relaxes the mind.

2.2 The Impact of Plant Environments on Physical and Mental Health

The degree of exposure to natural environments is considered a significant predictor of anxiety, with

more exposure to natural settings correlating with lower levels of anxiety[18]. Viewing plants in nature has been proven to effectively reduce stress, increase happiness, and improve mood[19-21]. Plants or images of plants have been shown to ameliorate "psychological distress" at lower levels and facilitate recovery from stress, addressing a broader spectrum of health issues[22]. In the UK, a study involving tens of thousands of individuals found that people living near green spaces experienced lower stress levels[23]. Similarly, research in the Netherlands indicated that in areas with more greenery, there were lower rates of psychological stress and the subsequent occurrence of depression and anxiety[24]. A study of over 11,000 residents in Denmark revealed that those living more than a kilometer away from green spaces reported higher stress levels[25]. Plants play many positive roles in urban environments, not only providing material benefits but also improving human physiological health development. Studies have shown that observing photographic images and real plant landscapes can produce stress responses that lower skin conductivity, heart rate, and other physiological indicators[26]. Van den Berg[27] found that a period of gardening activities could reduce stress more effectively than reading indoors. Furthermore, plant environments can also improve the health conditions of young people with mental health issues. Urban youth with Attention Deficit Hyperactivity Disorder (ADHD) can maintain better attention after spending time in park environments[28], alleviating symptoms of ADHD in adolescents[29].

2.3 The Impact of Plant Colors on Human Health

Research by Bringslimark has demonstrated that green plants can alleviate visual fatigue, shoulder stiffness, and back soreness in workers[30]. Other researchers have found that observing photographs and real plants in blue, yellow, and green leads to an increase in alpha waves and a decrease in beta waves in the subjects' brains, indicating that these colors can calm the state of the subjects. In contrast, red plants reduce alpha waves and increase beta waves, suggesting that red plants can disturb the subjects' state, leading to a lack of concentration[31]. Rooms with red geraniums have been shown to better promote users' skin conductivity and brainwave responses compared to rooms without geraniums or with non-flowering geraniums[32]. Plant color is an important indicator for improving public mental health[33], with warm colors exciting and accelerating breathing, while cool colors can calm, slow breathing, and bring brain waves into a state of calm and relaxation. Green and purple plants are more effective in relaxing the body, reducing anxiety, and improving mood compared to red, yellow, and white plants . Kaufman’s study[34] also found that plants with green canopies evoke more positive emotions in individuals than those with canopies of other colors.

Beyond their physiological and psychological effects, colors also have therapeutic and health benefits. Modern medicine has shown that colors can treat diseases: red stimulates the nervous system and promotes blood circulation; orange and yellow help eliminate fatigue and depression, and can alleviate tension, hesitation, and fear; yellow aids in focusing attention, strengthening logical thinking, and enhancing memory; green relieves eye fatigue and has a calming effect on the body; blue lowers pulse and blood pressure and stabilizes breathing; purple stimulates tissue growth, helps eliminate migraines and other diseases; and silver can treat diseases of the brain or nervous system, but should be used with caution[35].

3. Research Methods

The physical and mental health issues of college students have attracted increasing attention. The campus environment can help alleviate their emotions and improve their physical functions. However, it is not yet clarified which color of campus landscape can promote the physical and mental health of college students. This study initially focused on college students and applied psychological tests to

measure the changes in their psychological indicators after viewing plant landscape images of different colors, so as to offer a theoretical basis for the selection of plant colors in the construction of rehabilitative landscapes on university campuses. Additionally, it was expected to give a scientific theoretical basis for the application of plant colors and horticultural color therapy as well as the creation of a healthy and scientific living environment.

3.1 Research Design

This research was conducted through online survey questionnaires. The questionnaires were set and statistically computed using the "Wenjuanxing" online survey questionnaire tool and disseminated via various online social network platforms, and all of the surveys were filled and distributed online. (Wenjuanxing is a professional online questionnaire survey tool and platform, focusing on a series of services such as online questionnaire design, data collection, and survey result analysis, with obvious advantages of fast, ease of use, and low cost, which has been extensively applied by a large number of enterprises and individuals).

This survey is divided into two parts, comprising a total of 16 questions. The first part involves the participants completing a pre-test questionnaire (including a basic health information sheet and the Positive and Negative Affect Schedule) and collecting personal information such as undergraduate year, gender, and initial anxiety level. The level of anxiety is categorized into six areas: tension, nervousness, worry, sorrow, panic, and restlessness. Responses are measured using a 5-point Likert scale (ranging from "almost never" to "extremely") and scored from 1 to 5.

In the second part, to assess the different impacts of plant colors on alleviating college students' anxiety, five common plant color images—green, red, yellow, black, and white—were selected for the survey. Participants chose the color they felt was most effective in alleviating each type of anxiety, with a single choice set for each anxiety content and the corresponding relief level recorded. Responses are measured using a 5-point Likert scale (from "almost never" to "extremely") and scored from 1 to 5.

Before conducting the formal experiment, several rounds of pilot studies were carried out to refine the design of the main experiment and better guide its execution based on the results of these preliminary tests. The pilot study was conducted three times with a total of 10 participants. The purpose was to determine the differences in the psychological impacts of plant color images on individuals. The pilot study concluded that different plant colors have varying restorative effects on participants.

3.2 Research Instrument

3.2.1 Psychological Indices: The Positive and Negative Affect Schedule

The PANAS was introduced by D. Watson[36]. Subsequently, Chinese researchers conducted applicability tests within the Chinese population. The reliability (α) and validity (r) for Positive Affect (PA) and Negative Affect (NA) were found to be α PA = 0.85, α NA = 0.83, rPA = 0.65, and rNA = 0.62, respectively[37] .

3.2.2 The Anxiety Scale

According to Liu's definition of anxiety, the degree of anxiety was divided into six categories: nervousness, concern, worry, panic, anxiousness, and uneasiness. The questions were answered using a 5-level scale method ("almost no" to "extremely"), the anxiety emotions were scored on a scale of 1-5. The higher the score in each dimension, the higher level of the anxiety emotion .

3.2.3 The Alleviation Degree of Anxiety Emotions by Plant Colors

To assess the disparity in the alleviating effects of different plant colors on anxiety in college students, the most common five plant colors, green, red, yellow, black, and white, were selected for investigation. The experimental subjects selected the color (single choice) that they believed was the most effective in alleviating the emotion of each anxiety item and filled in the corresponding degree of alleviation. They answered the questions using a 5-level scale method (from "almost no" to "extremely"), which was scored on a 5-point scale. The higher the score, the higher the degree of alleviation.

3.3 Respondents of the Study

This study randomly selected college students with normal color vision from universities in Henan as participants. Before the experiment, participants filled out basic health information and the Positive and Negative Affect Scale (PANAS) to ensure their psychological state was evaluated as normal, they could understand the meaning of the scales, were capable of completing the assessment scales seriously and independently, and had normal color vision. The age of participants ranged between 18-26 years. Selection criteria for the study subjects included: having a certain level of education to complete the questionnaire seriously and independently; normal vision without color blindness or other visual impairments; healthy with no history of mental illness or cardiovascular diseases; and no consumption of alcohol, coffee, or other foods or medications that stimulate the sympathetic nervous system within 6 hours prior to the experiment.

3.4 Dota Gathering Procedures

Data were collected using the "Wenjuanxing" tool. The author distributed 818 online survey questionnaires using the Accidental Sampling method from October 13, 2023, to October 31, 2023, all of which were retrieved. In total, 50 questionnaires responded 'yes' to the question "Have you recently suffered a major blow? (such as serious disorders, car accidents, significant misfortune, etc.) were deleted. Ultimately, 768 valid questionnaires were determined, with a valid response rate of 93.8%. (The questionnaire survey was anonymously conducted to protect the privacy and personal information of the interviewees).

3.5 Statistical Tools

The data retrieved from the questionnaires were statistically analyzed by SPSS software to identify the differences among the results of different variables, discuss corresponding causes, and derive reasonable conclusions.

Pearson's correlation analyses were conducted using SPSS software to analyze the correlations among six anxiety emotions (nervousness, concern, worry, panic, anxiousness, and uneasiness).

An analysis of variance was carried out to compare the effects of different colors on the anxiety emotions of the subjects.

4. Research results

The reliability test of this questionnaire showed an overall standardized reliability of 0.937, and the reliability ranged between 0 and 1. The value closer to 1 the higher the reliability. The result of this analysis (0.937) suggested a relatively high reliability.

4.1 Baseline Characteristics of the Interviewees

The gender results showed that the proportion of male students was 57.0%, and that of female students was 43.0%. The education background results exhibited 27.0% of junior college students， 50.0% of undergraduate students, and 23.0% of postgraduate students [Table 1].

[Table 1] Baseline Characteristics of the Interviewees (n=768)

Social characteristics	Options	Frequency	Percentage
Gender	Male	440	57%
	Female	328	43%
Degree	Junior college	210	27%
	Undergraduate	387	50%
	Postgraduate	171	23%

4.2 Correlation Analysis among Emotions

Pearson's correlation analysis was conducted using SPSS software to analyze the six components of anxiety: nervousness, uneasiness, anxiousness, worry, panic, and concern emotions. The six variables showed significant correlations at a 99% significance level, and the correlation coefficients greater than 0.01 indicated their positive correlations [Table 2].

For instance, the correlation coefficient between nervousness and uneasiness was 0.822, suggesting a positive correlation. The correlations among all the other variables can be explained by analogy.

[Table 2] Correlations among Emotions

	Nervousness	Uneasiness	Anxiousness	Worry	Panic	Concern
Nervousness	1					
Uneasiness	.822**	1				
Anxiousness	.730**	.732**	1			
Worry	.778**	.780**	.760**	1		
Panic	.767**	.824**	.704**	.769**	1	
Concern	.647**	.636**	.670**	.647**	.578**	1

**. at the 0.01 level (two-tailed), the correlation was significant.

4.3 Alleviating Effect of Plant Colors on Nervousness Emotion

According to the survey results shown in Table 3, 56.64% of individuals believed that green was the most effective in alleviating nervousness, while 29.68% of individuals believed that white was most effective in alleviating nervousness.

The ANOVA analysis was utilized to explore the differences in the alleviating degree of plant colors on nervousness. As depicted in the table above, there was a significant difference ($p<0.05$) in the alleviating degree of different plant colors on nervousness. Furthermore, different colors showed significant differences in their alleviating effect on nervousness ($F=3.059$, $p=0.016$), and the mean scores of the groups with significant differences exhibited "green>white" results. Hence, green was indicated to exert a significantly higher alleviating effect on nervousness than white [Table 4].

[Table 3] Alleviating Effects of People's Color Choices on Different Anxiety Emotions

Name	Options	Frequency	Percentage (%)
plant colors alleviating nervousness	red	34	4.427
	green	435	56.641
	yellow	34	4.427
	white	228	29.688
	black	37	4.818
plant colors alleviating uneasiness	red	67	8.724
	green	296	38.542
	yellow	81	10.547
	white	230	29.948
	black	94	12.24
plant colors alleviating anxiousness	red	75	9.766
	green	302	39.323
	yellow	142	18.49
	white	221	28.776
	black	28	3.646
plant colors alleviating worry	red	67	8.724
	green	337	43.88
	yellow	86	11.198
	white	225	29.297
	black	53	6.901
plant colors alleviating panic	red	90	11.719
	green	347	45.182
	yellow	71	9.245
	white	202	26.302
	black	58	7.552
plant colors alleviating concern	red	108	14.063
	green	272	35.417
	yellow	152	19.792
	white	200	26.042
	black	36	4.688

[Table 4] Plant Colors Alleviating Nervousness (mean ± standard deviation)

	red(n=34)	green(n=435)	yellow(n=34)	white(n=228)	black(n=37)	F	p
Degree of alleviation	3.265±1.399	3.225±1.210	2.882±1.200	2.912±1.173	2.946±1.471	3.059	0.016*

* p<0.05 ** p<0.01

4.4 Alleviating Effect of Plant Colors on Uneasiness Emotion

Through the ANOVA analysis, the difference in the alleviating effect of different plant colors on uneasiness was found to be significant ($p<0.05$). Specific analysis revealed that plant colors had extremely significant differences in their alleviating impacts on uneasiness ($F=3.522$, $p=0.007$). The comparative analysis on the mean scores of the groups with significant differences showed results as "green>white; green>black; yellow>black; white>black" [Table 5].

[Table 5] Plant Colors Alleviating Uneasiness (mean ± standard deviation)

	red(n=67)	green(n=296)	yellow(n=81)	white(n=230)	black(n=94)	F	p
Degree of alleviation	3.045±1.248	3.270±1.276	3.111±1.129	3.048±1.172	2.734±1.438	3.522	0.007**

* p<0.05 ** p<0.01

4.5 Alleviating Effect of Plant Colors on Anxiousness Emotion

The survey results indicated that [Table 3], green was the most frequent to be selected among the colors in alleviating the anxiousness emotion, accounting for 39.32%.

The ANOVA analysis assessed the differences in the degree of plant colors alleviating anxiousness, and the data in Table 6 showed that the degree of alleviation was insignificant among different plant colors (p>0.05). From the perspective of selection frequencies, the results suggested that green was more effective in alleviating anxiousness [Table 6].

[Table 6] Plant Colors Alleviating Anxiousness (mean ± standard deviation)

	red(n=75)	green(n=302)	yellow(n=142)	white(n=221)	black(n=28)	F	p
Degree of alleviation	3.093±1.286	3.295±1.266	3.099±1.034	3.186±1.257	2.786±1.371	1.616	0.168

* p<0.05 ** p<0.01

4.6 Alleviating Effect of Plant Colors on Worry Emotion

The results of ANOVA analysis showed that different plant colors had no significant difference in their alleviating effect on worry emotion (p>0.05) [Table 7]. It was suggested that the difference in the alleviating effects of green, white, and yellow on worry emotion was insignificant.

[Table 7] Plant Colors Alleviating Worry (mean ± standard deviation)

	red(n=67)	green(n=337)	yellow(n=86)	white(n=225)	black(n=53)	F	p
Degree of alleviation	3.149±1.306	3.285±1.235	3.035±1.250	3.191±1.185	2.868±1.241	1.772	0.133

* p<0.05 ** p<0.01

4.7 Alleviating Effect of Plant Colors on Panic Emotion

As presented in [Table 8], no significant difference was noted in the alleviating effects of different plant colors on panic emotion.

[Table 8] Plant Colors Alleviating Panic (mean ± standard deviation)

	red(n=90)	green(n=347)	yellow(n=71)	white(n=202)	black(n=58)	F	p
Degree of alleviation	3.144±1.286	3.256±1.272	3.141±1.099	3.203±1.223	3.138±1.357	0.285	0.888

* p<0.05 ** p<0.01

4.8 Alleviating Effect of Plant Colors on Concern Emotion

The survey results [Table 3] showed that 35.41% of individuals selected green, 19.79% of individuals selected yellow, and 26.04% selected white among plant colors alleviating concern.

The ANOVA analysis was adopted to examine the differences in the use of plant colors to alleviate concern emotion. It was found that different plant colors had significantly different alleviating effects on concern emotion ($p<0.05$). Plant colors showed a significant difference in the degree of alleviating concern emotion at the 0.05 level ($F=2.484$, $p=0.042$). By comparing the differences in mean scores, it could be concluded that the mean scores of groups with significant differences were displayed as "green>yellow; green>white" [Table 9].

[Table 9] Plant Colors Alleviating Concern (mean ± standard deviation)

	red(n=108)	green(n=272)	yellow(n=152)	white(n=200)	black(n=36)	F	p
Degree of alleviation	3.278±1.142	3.426±1.304	3.053±1.041	3.200±1.272	3.167±1.483	2.484	0.042*

* p<0.05 ** p<0.01

4.9 A summary of the Alleviation Degree of Anxiety Emotions by Plant Colors

Different plant colors bring different visual senses to subjects. Based on the analysis of variance on the differences in the alleviation degree of anxiety emotions among subjects by different plant colors, the alleviating impacts of plant colors on anxiety emotions could be obtained.

As summarized in the Table, green, white, and yellow plants had an alleviating impact on the anxiety emotions of the subjects, and different plant colors contributed to different degrees of alleviating effects. Green plants exerted significant alleviating effects on nervousness, uneasiness, and anxiousness emotions; White plants had significant alleviating impacts on nervousness, nervousness, and concern; Yellow plants had significant alleviating effects on uneasiness and concern. Black plants showed a significant alleviating effect on uneasiness.

5. Results and Discussion

The study indicates that simply viewing images of plants in different colors can alleviate feelings of tension, unease, and worry, aligning with existing research findings[38-40].

This study demonstrates that green plants have the most significant restorative effect on negative emotions, consistent with current scholarly research[41-43]. Green is the color most associated with calmness and relaxation, capable of soothing those who are physically and mentally exhausted, fostering feelings of happiness and contentment[44]. Research suggests that when green occupies 75% of a person’s visual field in nature, it can make one's spirit feel comfortable[45]. This is because cool-colored plant hues (such as green and blue) can help the autonomic nervous system relax, enhance parasympathetic nerve excitation, and bring psychological activities into an optimal state[46]. Green also evokes feelings of safety and hope[47].

Yellow plants can soothe feelings of tension and fatigue and are the most likely to induce excitement while seldom triggering negative emotions. Yellow symbolizes health and is the brightest, most cheerful color among all colors. Therefore, yellow leaves a bright, splendid, radiant, happy, friendly, and soft impression, uplifting spirits and filling individuals with joy[48] . Its dual function is evident in its ability to stabilize emotions and enhance appetite in healthy individuals; however, it may exacerbate adverse

emotions in those who are emotionally suppressed, pessimistic, or disappointed. Studies have found that warm-colored plants can stimulate changes in heart rate and brain waves more, leading to an excited state[49]. When viewing photographs and real plants in yellow and green, an increase in alpha waves and a decrease in beta waves in participants' brains indicate that these colors can positively affect the subjects' state .

In this study, red did not perform as well as other colors, which might be attributed to red's association with excitement or alertness, leading to an increased pulse rate and rapid breathing. Moller posited that red is positively correlated with negative emotions and negatively correlated with positive emotions . Other scholars believe that red plants can disturb the state of participants, leading to a lack of concentration[50]. However, in this experiment, the restorative effects on emotions by black and red plants were not as significant as those by white and green plants. This discrepancy might relate to participants' color preferences. Research by N. Kaya suggests that the impact of color on emotions depends on individual preferences towards colors, which vary due to differences in age, religion, culture, gender, etc[51]. This aligns with the conclusions of this study, indicating the need for further investigation into color preferences within this demographic.

The study found the sequence of plant colors with significant restorative effects on tension to be: green, white; and for unease: green, white, yellow, black; specifically for anxiety: green, white, yellow. Based on this, it is recommended to extensively plant green and white plants in the construction of campus landscapes that improve the mental and physical health of college students, complemented by yellow plants. This aims to reduce students' academic stress and enhance learning efficiency.

Horticultural therapy establishes a relationship between people and plants through plant factors, between people and the natural environment through environmental factors, and between people and activity sites through activity factors, thereby achieving a positive impact on individuals' physical and mental health. Sensory stimulation is fundamental to horticultural therapy, which, by stimulating people's vision, smell, touch, hearing, and taste, aims to achieve therapeutic objectives, demonstrating a comprehensive approach. The results of this study align with the plant color healing aspect of horticultural therapy. Based on horticultural therapy's color therapy and aromatic therapy, integrating plant design with psychology, color theory, sociology, and other disciplines provides a more comprehensive theoretical basis and design foundation for plant design. It offers more scientific and effective optimization suggestions for creating restorative environments in campus landscapes.

Research in environmental psychology has validated that certain positive features within an environment can offer restorative experiences to its inhabitants, including mitigating mental stress, reducing psychological fatigue, and alleviating negative emotions, thus aiding in the recovery of mental and physical health issues. The theory of "Restorative Environments" has confirmed the significant effectiveness of natural environments in alleviating mental stress among populations. Campus green landscapes serve as the most effective natural environmental resource for college students to intimately connect with nature. As the daily living space for college students, the quality of campus landscape design is crucial for students within the institution. Students not only learn in classrooms but also grow within the campus environment, which should not only be a green landscape but also possess health functions such as stress recovery and fatigue relief. Therefore, studying and assessing the quality of campus green landscapes from the perspective of restorative environments is of great importance. This study, through investigating the relationship and impact between the restoration of plant color environments and college students' anxiety, proposes more scientific and effective optimization suggestions for creating restorative environments in campus landscapes. Finally, based on the data results, suggestions are made to enhance the restorative effect of campus landscapes, steering the development of university campus landscapes towards a healthier and more positive direction. It also calls for increased attention from society and schools to the mental health of contemporary college students.

Limitations：①The research methodology primarily relied on questionnaires for data collection, which inherently carries a degree of subjectivity and inaccuracy. Where conditions permit, the use of advanced instruments such as EEG, eye-tracking devices, and VR for quantitative human studies can yield more rational and objective data, although this approach requires a greater willingness to participate from respondents.②The options provided in the questionnaire for alleviating anxiety among college students through plant colors were not entirely comprehensive. Colors can evoke a wide range of sensations, but due to considerations of questionnaire feasibility, not all related terms were included. Instead, a selection of typical words related to human emotions was used, which may introduce some bias and suggestiveness.③The study was limited by the selection of only solid plant colors for comparison, which is somewhat restrictive. Future research could explore a wider array of color combinations to better guide plant design.④Whether the brightness, purity, and saturation of plant colors have a significant impact on physiological and psychological effects has not been thoroughly investigated. Future studies could delve deeper into systematic experimental research on this aspect.

The current study focuses on the short-term recuperative effects on college students, but the subtle and profound influence of the environment should not be underestimated. Therefore, future research will design a longer time frame, utilizing mixed-color plant environments and employing EEG, eye-tracking devices, and VR for quantitative human studies to further explore the impact of campus green spaces on the physical and mental health of college students living there over the long term.The plant environment provides a comprehensive sensory experience. While vision has been repeatedly proven to be the primary channel through which humans perceive the world, it is not the only sense. There could also be a combined sensory experience involving vision, smell, taste, hearing, and touch. Moreover, how these five senses interact, constrain, and enhance each other could have various impacts on human physical and mental health. Therefore, research on the restorative study for college students will also involve a comprehensive analysis from the perspective of human multi-dimensional sensory organs to obtain more specific and accurate research results.

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