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Study on the Relationship between Restoration Benefit and Visual Satisfaction of LONG-PLAN's Indoor Vertical Greenery

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Abstract: This study investigates the psychological restorative benefits of indoor vertical greenery and its relationship with visual satisfaction. Taking the Solar Decathlon China 2018 champion project "LONG-PLAN" as the experimental field, we conducted a questionnaire survey to evaluate the effect of indoor vertical greenery on creating a restorative environment. Then we further studied the relationship between the restorative environmental factors and visual satisfaction of indoor vertical greenery. The results show that: (1) Indoor vertical greenery has a positive impact on the subjective restoration of respondents (the average value of PRS = 4.150). (2) The three factors of "being away," "fascination and compatibility," and the "extent" of environmental restoration have a significant positive correlation with the visual satisfaction of indoor vertical greenery (the correlation coefficient values are 0.403, 0.627, and 0.425, respectively, $p < 0.01$). (3) In the stepwise regression analysis of the three factors and the visual satisfaction of indoor vertical greenery, only "fascination and compatibility" show a significant positive correlation (the regression coefficient = 0.753, $p < 0.01$). (4) The visual satisfaction of indoor vertical greenery has a significantly positive impact on environmental recovery (the regression coefficient = 0.459, $p < 0.01$). The study shows that indoor vertical greenery improves visual satisfaction and contributes to a restorative environment. In addition, the study provides further evidence of the mutual facilitation between restorative benefits and visual satisfaction.

Keywords: indoor vertical greenery; restorative environment; attention restoration theory; healing design

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1. Introduction

The rapid development of society and the accelerated pace of life have led to various psychological problems. Studies have shown that indoor greenery helps relieve stress and benefits health [1]. The emergence and application of indoor greenery can be traced back to the 15th century. The cross-communication within Eurasia facilitated the spread of tropical plants to Europe, and plants were only moved indoors to survive the winter. In the mid-20th century, greenhouse technology matured and provided favorable physical conditions such as light quality for the healthy growth of indoor plants, which promoted the widespread use of indoor greenery [2]. Given the phenomenon of people's long-term aesthetic preference for natural features, environmental psychologists explain it mainly based on evolution theory. The biophilia hypothesis states that natural features tend to trigger the liking and attention of human beings [3]. Based on this evolutionary hypothesis, nature is beneficial in alleviating stress and mental fatigue and provides the so-called restorative experience [4]. The demand for a restorative environment is not exclusively for patients but also for general health [5]. In light of the pandemic of COVID-19, isolation within cities, communities, and homes further highlights the ongoing concern regarding healthy indoor environments.

1.1. Overview of Restorative Environment Research

Passive or active contact with nature can provide various positive health benefits. Therefore, the evaluation of the health benefits of built landscapes is gradually becoming a trending topic in the field of landscape design research. Since the 21st century, the number of empirical studies on the health benefits of natural landscapes has proliferated. The existing research on health benefits can be divided into that on the objective environment and subjective psychology. In the objective environment, the research focuses on evaluating Objective Environmental Quality (IEQ) standards corresponding to physical health, such as air quality, thermal comfort, acoustic comfort, and visual comfort [6]. In subjective psychology, the research focuses on the subjective psychological evaluation of environmental users' well-being and emotional health [7,8], and few studies have explored their specific psychological impact mechanisms.

Secondly, the research on health benefits has a wide range of environmental and spatial scales [9], which can be divided into those for outdoor and indoor environments. Research on the health benefits of outdoor space shows that trees, forests, and other urban natural elements help people reduce stress and improve cognitive performance [10]. In addition, college students' active participation in green space activities can regulate their emotions and reduce pressure [11]. The research on indoor health benefits shows that an office or a ward decorated with green plants provides better health benefits [12,13], promotes the recovery of disease and stress [1], and increases positive emotions [14]. In addition, a green indoor environment facilitates working productivity [15]. In other words, the natural environment has the characteristics of a restorative environment, which can provide people with a series of positive physiological and mental health benefits.

1.2. Research Progress of Restorative Environment

Abundant researches and practices on the restorative environment have been progressing worldwide. A restorative environment refers to an environment that promotes people's health and well-being [16]. It separates "health" from the traditional medical field and extends it to a multifaceted and generalized health. Based on the theories of attention restoration theory (ART) [17] and stress recovery theory (SRT) [18], researchers have developed the Perceived Restoration Scale (PRS) [19] and Restorative Components Scale (RCS) [20] for subjective mental health evaluation of a restorative environment. Among them, this paper focuses on the research and application of ART, which was formally proposed by the Kaplans in the 1980s. ART mainly elucidates the restorative benefits of the natural environment from the level of cognitive health and proposes four typical characteristics of restorative environments: "being away," "fascination," "compatibility," and "extent" [21]. The theory provides a theoretical basis for the study of restorative environmental benefits. Although research findings in environmental psychology have proliferated in recent years, there is a lack of attention on the residential environment in terms of architectural design disciplines. Existing studies have focused on the health benefits of outdoor natural environments [22,23], and few studies have included the indoor environment of buildings as an object of study. Although some scholars have proposed that the research results on restorative environments should be applied to the practical design of indoor environments, there are few pieces of literature to implement in practice, except the recent research by Xu et al. [24].

1.3. Study on Influencing Factors of Restorative Environmental Restoration Benefits

For the research on the influencing factors of the restorative benefits of a restorative environment, more and more scholars have paid attention to the relationship between the objective environment and subjective psychology. For example, many studies have explored the relationship between the perceived restorative benefits of restorative environments and a variety of subjective factors such as behavior, mood, cognition, attention, and well-being [25,26], as well as the specific effects that different restorative environments have on people. A small number of studies have discussed the deeper psychological mech-

anisms underlying the restorative benefits of rehabilitative environments for people [27]. In addition to environmental characteristics, there are differences in the impact of people's psychological mechanisms on health. Studies have found that people perceive the natural environment to be more aesthetically pleasing than the built environment, resulting in emotional improvement and higher concentration levels [28]. In addition, naturalistic gardens are perceived to have more restorative benefits than geometric gardens because naturalistic gardens are regarded as more visually appealing, which further facilitates environmental restoration [29]. It can be seen that people's evaluation of the restorative benefits of the restorative environment is affected by the evaluation of subjective visual beauty. However, the question of exactly how the evaluation mediates the potential for environmental restoration, and how its role influences the design of indoor health environments, has still not been thoroughly investigated. Therefore, this paper will further explore the relationship between the benefits of a restorative environment and visual satisfaction.

In summary, the health benefits of the natural environment have received widespread attention from researchers. However, most studies have focused on outdoor spaces while neglecting the benefit potential of indoor green spaces, and the mechanisms of influence between environmental recovery and environmental elements have rarely been explored in depth. As the most frequently used space for people's daily study, work, and life, the indoor space has a subtle influence on people's mental health. At the same time, since the characteristics of the indoor environment are more closely related to people's visual perception, it is meaningful to study the influence of an indoor green restorative environment on people's health benefits. Moreover, exploring the relationship between the restorative environment and people's satisfaction with visual effects is conducive to the design guidance of indoor environments and human health and well-being.

This paper explores whether green plants in the indoor environment can provide restorative benefits for human health and their relationship with visual satisfaction based on attention recovery theory (ART). We took "LONG-PLAN" as an example to evaluate the restoration of indoor vertical greenery through questionnaires combined with a single field experience and virtual image comparison. In addition, the correlation between environmental restoration factors and visual satisfaction with indoor vertical greenery was studied based on SPSS quantitative analysis to promote the project's iterative design. Then, we further explored interior landscape design principles and optimization measures, expecting to guide the design of more psychologically sustainable urban living environments.

2. Materials and Methods

2.1. Experimental Settings

The experimental site "LONG-PLAN" (Figure 1) was the winning project of Solar Decathlon China 2018 (SDC2018), the aim of which was to advocate for sustainable housing design by examining the sustainable performance of each entry in architecture, engineering, marketing, and energy. Situated in a high-density urban context, LONG-PLAN inherited the narrow–long shape and the emblematic light well from the bamboo house, a historical dwelling typology prevalent in tropical and subtropical Asia. Taking advantage of the inherent merits of its architectural morphology, in LONG-PLAN, three parallel stripes of space—one each for systems, service functions, and living functions—ran from front to back to obtain spatial efficiency as necessary in the extreme spatial proportion. Meanwhile, three vertical light cores were rhythmically interpolated, together with the space stripes optimizing the microclimate performance, including natural ventilation, daylighting, and thermal regulation [30].

Two of the three vertical light cores integrated a vertical greenery system and later became the setting for the experiment in this study. The core closer to the kitchen adopted an aquaponic system to grow fish and edible plants, while the largest and more ornamental-oriented core at the center was openable to become an open-air atrium. Both interior landscapes merged into daily living that was beyond a flat scenery (Figure 2).

The research samples consisted of 60 participants who visited the LONG-PLAN at least once. There were 24 males and 36 females aged 18–24 years, with an average age of 20.

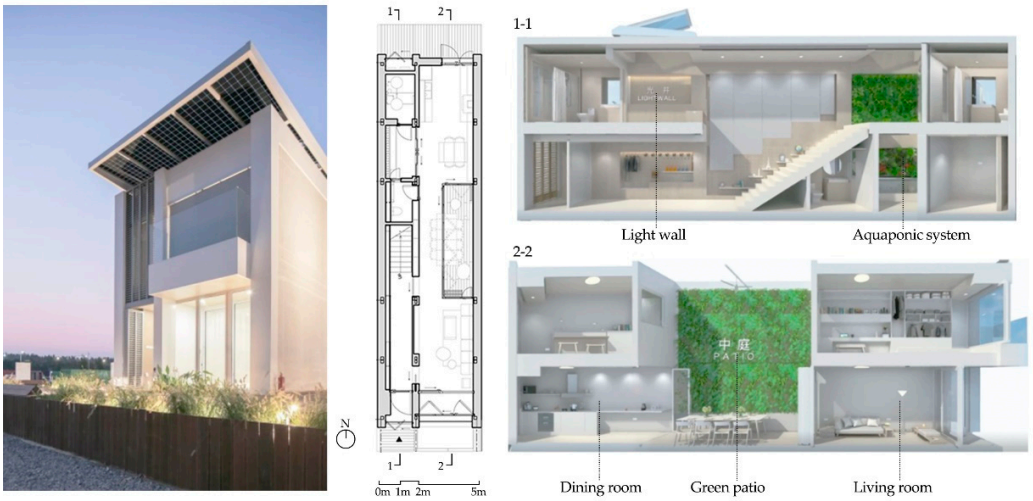

Figure 1. Real view and section schematic of LONG-PLAN.

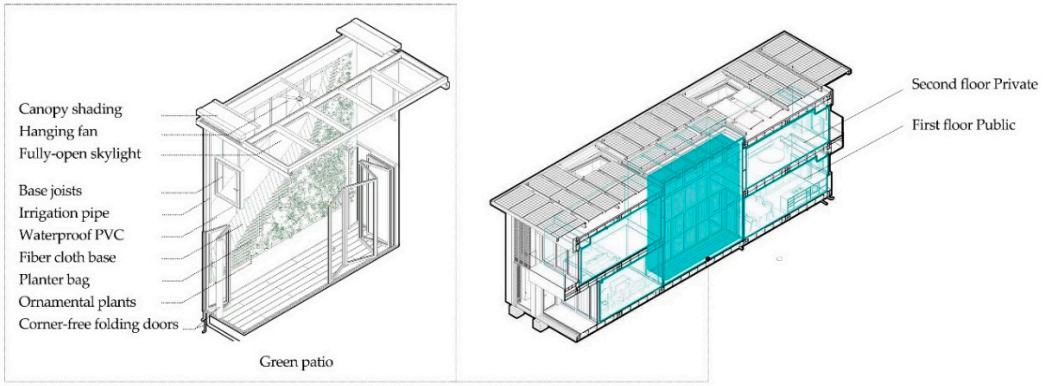

Figure 2. Axonometric diagram of the ecological core of LONG-PLAN.

2.2. Research Design

Unlike the general way of controlling experiments, such as building a small unit module or laboratory room, the experimental site of this study is in a real habitable house. Specifically, we selected the living room, green patio, and dining room on the first floor of the LONG-PLAN as fixed points (Figure 3), and each indoor scene has vertical greenery systems within the range of sight. These three scenes are in different locations in a long interconnected space, with similar dimensions and visual connectivity. Before the experiment, we first introduced the basic process of the experiment and the knowledge of indoor vertical greenery to the participants. Then, we gave participants a brief fatigue induction procedure—to imagine arriving at the house after a school course examination and assuming that the room would be your daily living space. An experimental field study of stress relief in an urban green space showed that significant mood changes have been reported by participants after they took a 20-min leisure walk in an urban park and all negative emotions were significantly decreased [31]. Therefore, drawing on that experiment, in this study, each participant was assigned a scene by the staff and sat quietly on the first floor for 20 min to experience the environment. To avoid interference from other participants, only three participants and one staff member were allowed to share the same space level in each round of the experiment. After observing the environment for 20 min, each participant came to the second floor of the LONG-PLAN and completed the

questionnaire to evaluate the perceptual restoration benefits of the indoor vertical greenery. Meanwhile, the next round of participants entered the first floor of the LONG-PLAN to do the 20-min environmental experience. The purpose of setting up the environmental experience and questionnaire filling process on two levels was to reduce mutual interference between participants and to save the experiment time. Lastly, after the participants had completed the questionnaires, we conducted a brief interview on their feelings about the environmental experience (Figure 4).

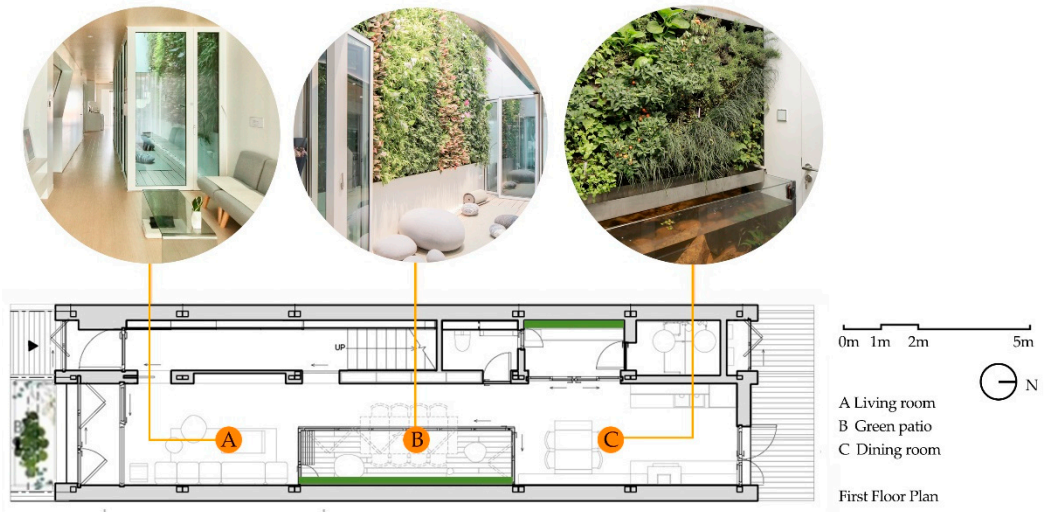

Figure 3. Fixed point plan of the experimental sample.

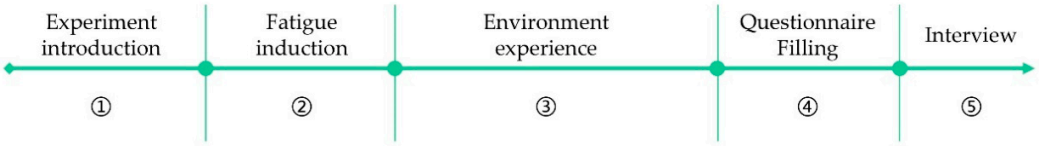

Figure 4. Experimental process.

2.3. Questionnaire Setting

Vertical greenery can improve the aesthetic value of the indoor environment. Moreover, the friendly interaction with nature may relieve individuals' psychological stress. Based on the above discussion on the research progress of health benefits and indoor restorative environment, we hypothesized that:

(1) Indoor vertical greenery has a positive effect on the construction of an indoor restorative environment.
(2) The restorative characteristic of indoor vertical greenery has a positive effect on participants' visual satisfaction.
(3) Participants' visual satisfaction has no significant effect on the overall restorative evaluation of indoor vertical greenery.

Based on the methodology of previous literature research, this study adopted single response and rating scale items, and the specific item setting referred to the Chinese version of the Perceived Restoration Scale (PRS) [32]. It was divided into three dimensions, namely, "being away," "fascination and compatibility," and "extent," and contained 22 items in total. The scale was adjusted according to the specific situation of this project by deleting 6 items that did not fit the context of this project, merging 2 items with duplicate meanings, converting 1 expression, and, finally, obtaining 15 items for this study (Appendix A). In this way, the content of the scale could be more easily understood by the participants. The Chinese version of the PRS and the scale of this project are shown in the Table A2. We retained the three dimensions of the PRS: "being away," "fascination and compatibility,"

and "extent." The score of each dimension was the average of the item scores on the 5-point Likert scale. The higher the score on the scale, the more positive the physical and psychological state response. In addition, we evaluated the participants' visual satisfaction with indoor vertical greenery to further explore the relationship between environmental restoration and satisfaction.

2.4. Data Analysis Strategy

We preprocessed the collected questionnaire data in Excel and entered it into SPSS 25.0 for Windows software for statistical analysis. Since "extent" is an antonymous question item, we processed the data by reversing the scoring, e.g., transforming all 5 points to 1 point and all 4 points to 2 points, etc.

Firstly, we analyzed the reliability and validity of the questionnaire. Secondly, we calculated the average value and the standard deviation of each item and drew the box-plot, which comprehensively reflects the overall evaluation of the restoration factors of LONG-PLAN. Finally, we conducted correlation analysis and regression analysis on the environmental restoration factors and visual satisfaction of indoor vertical greenery and explored the influence relationship between them.

3. Results

The results demonstrated that:

(1) The participants have a relatively high evaluation of the restoration of indoor vertical greenery, which means that indoor vertical greenery has a positive impact on users' subjective restoration.
(2) The three factors of environmental restoration, "being away," "fascination and compatibility," and "extent, " are positively correlated with the visual satisfaction of indoor vertical greenery.
(3) In the regression analysis of the three factors and the visual satisfaction of indoor vertical greenery, only "fascination and compatibility" show a significant positive correlation; the other two show no significant correlation.
(4) The visual satisfaction shows a significant positive effect on environmental restoration.

The specific analysis is as follows.

3.1. Reliability and Validity Analysis

The number of valid questionnaires was 60, and the recovery rate was 100%. The results show that the values of Cronbach's Alpha (reliability coefficient) are greater than 0.8 (Table 1), so the scale has high internal consistency, which could be regarded as good reliability. Regarding "Cronbach's Alpha if item deleted," whichever item we removed from the questionnaire, the reliability coefficient did not increase significantly. This indicates that the item should not be deleted.

This questionnaire refers to the Chinese version of the perceptual recovery scale (PRS) [32] with validity verified by previous literature research, so the content validity is good. It can be seen from the correlation matrix that the correlation between each dimension and the total score is higher than that between each dimension, indicating that the scale has good structural validity (Table 2).

3.2. Overall Evaluation of PRS

The results of the overall evaluation of PRS are shown in Table 3. The dining room was the most restorative environment of the different scenarios, followed by the living room and green patio. The average value of PRS was 4.150, which is higher than 4, indicating that the environmental restoration score of the indoor vertical greenery was relatively high. The score of "extent" was the highest (4.304 ± 0.813), followed by "fascination and compatibility" ($4.\ 280 \pm 0.659$), and "being away" was relatively low ($3.\ 758 \pm 0.731$) (Table 3).

Table 1. Reliability statistics.

Items		Cronbach's Alpha If an Item Deleted	Cronbach's Alpha
(1) Visual satisfaction of the indoor vertical greenery		0.889	0.896
Being Away	(2) It keeps me away from a lot of stress in real life.	0.885	
	(3) It's a lot different from the environment I'm exposed to in my daily life.	0.895	
	(4) When I'm here, I don't have to ponder over my responsibilities.	0.905	
	(5) Staying here gives me a good break from my daily chores.	0.895	
Fascination and Compatibility	(6) This environment gives me a novelty.	0.882	
	(7) I can see, listen, feel and ponder over a lot of things here.	0.892	
	(8) My attention is drawn here.	0.885	
	(9) It makes me feel comfortable here.	0.883	
	(10) Living here, I can do what I like.	0.886	
	(11) I want to stay here longer.	0.884	
	(12) It can evoke my recollection or imagination.	0.897	
Extent	(13) I think this environment is boring.	0.886	
	(14) I think the environment is very monotonous.	0.888	
	(15) I feel like it's chaotic here.	0.888	
	(16) I'm going to feel very upset here.	0.892	

Table 2. Pearson correlation between dimensions and the general score of PRS.

	The General Score	Being Away	Fascination and Compatibility	Extent
The General Score	1			
Being Away	0.759 **	1		
Fascination and Compatibility	0.916 **	0.616 **	1	
Extent	0.781 **	0.379 **	0.583 **	1

Note: ** $p < 0.01$.

Table 3. Total and dimensional scores of PRS.

	Scene			Sum (n = 60)
	Dining Room (n = 17)	Living Room (n = 22)	Green Patio (n = 21)	
Being Away	3.912 ± 0.795	3.682 ± 0.583	3.714 ± 0.826	3.758 ± 0.731
Fascination and Compatibility	4.370 ± 0.649	4.390 ± 0.473	4.089 ± 0.807	4.280 ± 0.659
Extent	4.340 ± 0.750	4.364 ± 0.685	4.167 ± 0.988	4.304 ± 0.813
Score of PRS	4.226 ± 0.631	4.145 ± 0.456	3.990 ± 0.709	4.150 ± 0.599

The boxplot represents the central tendency, the skewness, and the trend of data distribution through the median, quartiles, and interquartile range to comprehensively understand the participants' evaluation of the restoration and visual satisfaction of indoor vertical greenery. As seen from the box plot, the ratings of the four question items of "being away" were generally high. Except for the first question and the third question, where there existed individual respondents who rated 1, all of them were 3–5 (Figure 5a); the seven question items of "fascination and compatibility" were highly rated overall, with the ratings of the first six questions concentrated between 4–5 and the last one 3–4, but there existed individual ratings of 1 and 2 (Figure 5b); "extent" was reverse scored, and the ratings of the first three question items were high overall, mostly 3.5–5 points, but the rating of the 4th question was more scattered, except for the main focus on 5 points, 1–4 points had a scattered distribution (Figure 5c). The average score of the evaluation of the visual satisfaction of indoor vertical greenery was more significant than 4, which was high overall (Figure 5d).

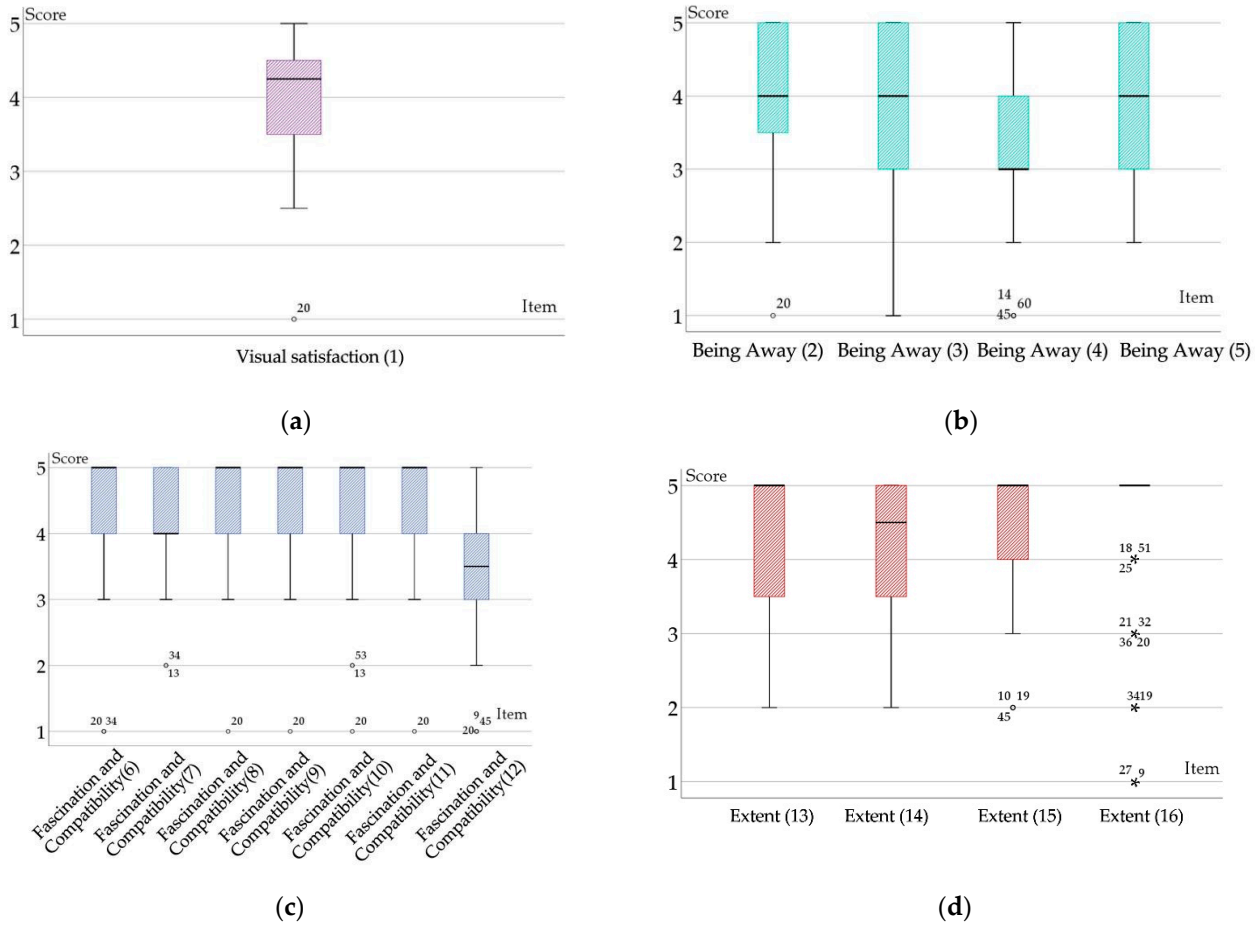

Figure 5. The boxplot: (**a**) visual satisfaction of the indoor vertical greenery; (**b**) being away dimension evaluation; (**c**) fascination and compatibility dimension evaluation; (**d**) extent dimension evaluation. (Note: * and ○ are extreme values.)

To sum up, from the analysis results of the descriptive analysis and box diagram, it can be seen that the participants generally scored relatively high on the restoration of the indoor vertical greenery. In other words, the indoor vertical greenery positively impacts the construction of the indoor restorative environment, which can verify hypothesis 1. Furthermore, from the dimension, participants have the highest evaluation of the "extent." That is to say, indoor vertical greenery has a good effect on improving the "extent" characteristics of the restorative environment. It can attract people's spontaneous attention and bring a positive psychological impact. Our study also verifies the results of relevant studies [33]; a green environment can induce positive emotions and help restore attention.

3.3. Relationship between PRS and Visual Satisfaction of Indoor Vertical Greenery

3.3.1. Pearson Correlation Analysis

We utilized Pearson correlation analysis to study the relationship between the "visual satisfaction of the indoor vertical greenery" and "being away," "fascination and compatibility," and "extent," respectively.

The specific analysis shows that: the correlation coefficient values of "visual satisfaction of the indoor vertical greenery" and "being away," "fascination and compatibility," and "extent" were 0.403, 0.627, 0.425, respectively. All present significance at a 0.01 level (Table 4). Therefore, the visual satisfaction of the indoor vertical greenery has a significant positive correlation with the three dimensions, verifying hypothesis 2.

Table 4. Pearson correlation analysis between the three dimensions of PRS and visual satisfaction of indoor vertical greenery.

	Visual Satisfaction	Being Away	Fascination and Compatibility	Extent	Scores of PRS
Visual Satisfaction	1				
Being Away	0.403 **	1			
Fascination and Compatibility	0.627 **	0.588 **	1		
Extent	0.425 **	0.365 **	0.584 **	1	
Scores of PRS	0.606 **	0.759 **	0.916 **	0.780 **	1

Note: ** $p < 0.01$.

From the perspective of specific items, except for item 3 "When I'm here, I don't have to ponder over my responsibilities," which did not show a significant correlation with the visual satisfaction of indoor vertical greening, the other 14 items had a positive correlation (Figure 6).

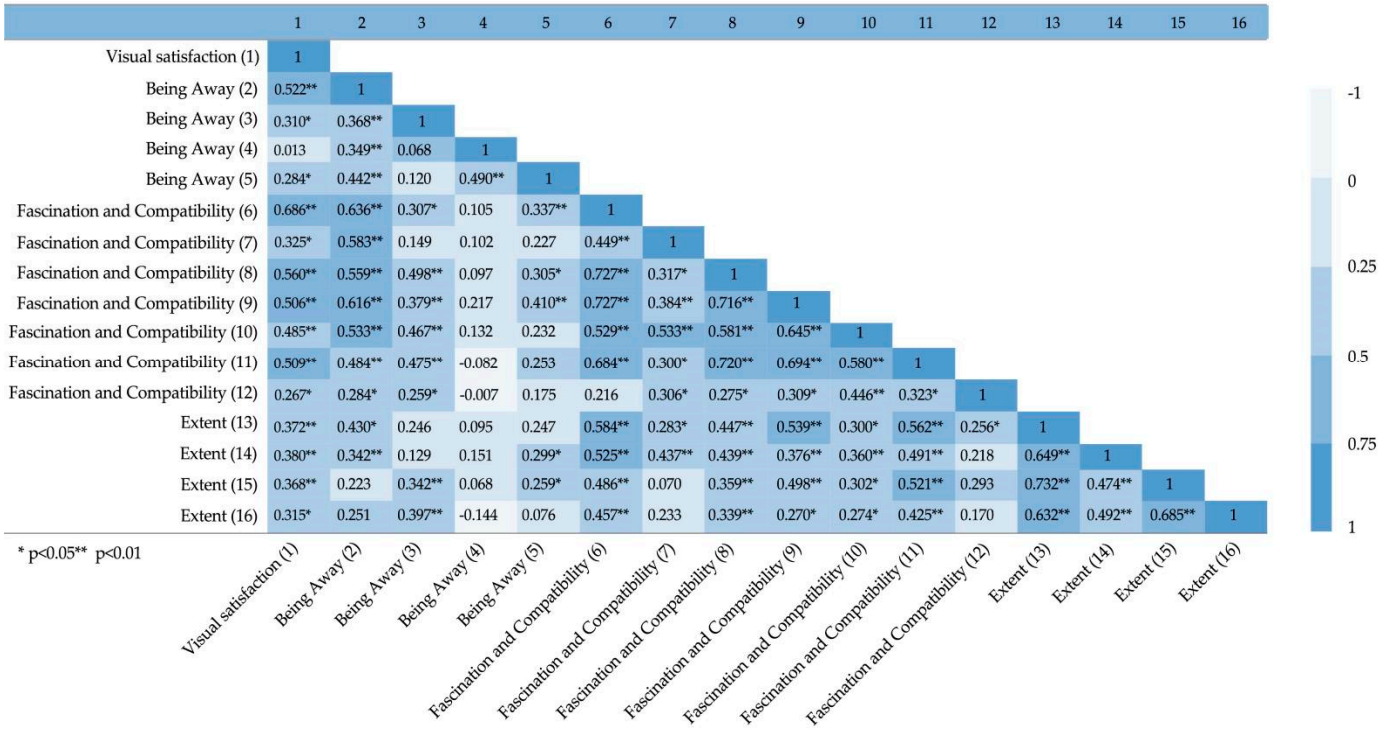

Figure 6. Pearson correlation analysis between visual satisfaction and items of PRS. (Note: * $p < 0.05$, ** $p < 0.01$.)

3.3.2. Regression Analysis

- Stepwise Regression

We took "being away," "fascination and compatibility," and "extent" as independent variables and took "visual satisfaction" as a dependent variable for stepwise regression analysis. After automatic model identification, there was only "fascination and compatibility" left in the model. The model formula is:

$$\text{visual satisfaction} = 0.811 + 0.753 * \text{Fascination and Compatibility} \quad (1)$$

The R-square value was 0.393, which means that the model explains 39.3% of the fitted data in the regression model. Moreover, the model passed the F-test ($F = 37.568$, $p = 0.000 < 0.05$), indicating that the model is effective. The regression coefficient of "fascina-

tion and compatibility" was 0.753 (t = 6.129, $p = 0.000 < 0.01$), which means that "fascination and compatibility" have a significant positive impact on the visual satisfaction of indoor vertical greenery (Table 5). This result also verifies hypothesis 2.

Table 5. Results of stepwise regression analysis ($n = 60$).

	Unstandardized Coefficients		Standardization Coefficient	t	*p*	VIF	R^2	Adjusted R^2	F
	B	SE	Beta						
Constant	0.811	0.532	-	1.524	0.133	-	0.393	0.383	F (1, 58) = 37.568
Fascination and Compatibility	0.753	0.123	0.627	6.129	0.000 **	1.000			$p = 0.000$

Note: Dependent variable: visual satisfaction, Durbin–Watson value: 1.238, ** $p < 0.01$.

- Linear Regression Analysis

We took the visual satisfaction as the independent variable and the scores of PRS as the dependent variable for linear regression analysis. As can be seen from Table 6, the model formula is:

$$\text{Scores of PRS} = 2.294 + 0.459 * \text{visual satisfaction} \quad (2)$$

Table 6. Results of linear regression analysis ($n = 60$).

	Unstandardized Coefficients		Standardization Coefficient	t	*p*	VIF	R^2	Adjusted R^2	F
	B	SE	Beta						
Constant	2.294	0.325	-	7.057	0.000 **	-	0.368	0.357	F (1, 58) = 33.729,
Visual Satisfaction	0.459	0.079	0.606	5.808	0.000 **	1.000			$p = 0.000$

Note: Dependent variable: Scores of PRS Durbin–Watson value: 1.942, ** $p < 0.01$.

The R-square value of the model was 0.368, which means that the model explains 36.8% of the fitted data in the regression model. During the F-test of the model, it was found that the model passed the F-test (F = 33.729, $p = 0.000 < 0.05$), which means that the visual satisfaction has an impact on the scores of PRS. The final specific analysis shows that the regression coefficient of visual satisfaction was 0.459 (t = 5.808, $p = 0.000 < 0.01$), which means that the visual satisfaction has a significant positive impact on environmental recovery (Table 6). It proves that hypothesis 3 is not tenable.

4. Discussion

Previous research on restorative environments primarily focused on the restoration benefits of healing landscapes such as medical spaces. In modern high-density urban environments, where people spend most of their time indoors [34], a restorative interior should serve as an important spatial means of regulating and alleviating mental health conditions. In this context, this paper argues that research on the restorative benefits of daily living places is necessary, i.e., to investigate how environmental characteristics benefit mental and physical health.

The results of this study reveal that people show a stronger preference for indoor environments with natural elements such as vertical greenery, which have a positive impact on mental health. In the results, each of the three factors of restoration "being away," "fascination and compatibility," and "extent" has a significant positive correlation with the visual satisfaction of indoor vertical greenery. However, when the three factors are taken as independent variables to study their relationship with the visual satisfaction of indoor vertical greenery, only "fascination and compatibility" show a significant positive correlation. The results with the largest contribution to the dimension of "fascination and compatibility" are consistent with the results of Ye et al. on the relationship between

outdoor environmental restoration and preference [32]. In addition, in the final interviews of this study, most participants' first impression of the indoor vertical greenery was the sense of nature and refreshment. Moreover, they were surprised by the novelty of this natural experience and also by its visual appearance, as they had not had such a natural visual and living experience in their dwellings before. In other words, an indoor living environment with vertical greenery is more attractive than one without greenery. It can be seen that the indoor vertical greenery environment attracts people's attention by improving the freshness of the architectural landscape environment to a great extent. Furthermore, it also enhances the feeling of being physically and mentally integrated with the environment, thus enhancing the healing benefits of the environment and improving the comfort and satisfaction of people's experience in the environment. In turn, increased satisfaction can significantly improve environmental restoration. That is, vertical greenery is effective as a visual feature of the indoor environment and has great potential to create a restorative environment. It supports psychological recovery by linking architecture and nature, drawing directed attention, and evoking aesthetic experiences.

Therefore, a restorative interior can be designed from the perspective of improving the attractiveness of the landscape by focusing on the healing environmental characteristics of "fascination and compatibility", thus improving visual satisfaction and environmental restorative benefits. Our work provides supporting evidence for the design hypothesis and validates Dijkstra et al.'s research conclusion [4]. Based on the results of this study, the following points can be noted in the design of indoor vertical greenery to improve the attractiveness of indoor vertical greenery, thus enhancing the restorative benefits and improving visual satisfaction.

(1) Select more attractive types of indoor vertical greenery. Firstly, designers should take into account the plant richness, color, texture, and other factors to create a more attractive and better visual effect of indoor vertical greenery. Secondly, combined with the interview results, vegetable edible plants are more popular than other plants in terms of plant categories; therefore, the application of edible plants in indoor vertical greenery can be strengthened. Finally, designers should combine the physical conditions of specific spatial locations to select vegetation with corresponding growth conditions, such as choosing light-loving vegetation types in locations with good natural lighting and ventilation to ensure the optimal vegetation growth effect.
(2) Optimize the spatial experience of indoor vertical greenery. Indoor vertical greenery should be set up with an emphasis on space size, lighting factors, and other conditions. In the case of good basic physical conditions, try to set it at the sight corridor between the family activity center and each space, and leave a certain viewing distance. The area of indoor vertical greenery should be as large as possible to form a shocking visual impact and optimize the landscape effect. In this regard, vertical greenery devices have more vital visual advantages and great potential for physical interaction between users and the greenery due to the inevitable vertical layout. Therefore, some auxiliary facilities can be installed near indoor vertical greenery to provide a sense of natural experience and a stress-relieving resting place for close contact.

In the face of the growing challenge in the relationship between habitat and health, design will no longer be the endpoint but an important intermediate in the cycle of "research–design–evaluation–improvement–research" [35]. As mentioned above, the biophilic hypothesis explains the beneficial effects of natural elements on mental health. Biophilic design enhances people's ability to recover from mental and physical stress by improving the quality of the space environment and meeting people's healthy psychological needs in the process of imitating nature [33]. This study shows indoor vertical greenery is one of the effective applications of biophilic design theory on an architectural scale. This study also presents a design tool for architects based on the subjective perceptions of users based on PRS. Designers can better understand the interactions between people and indoor greenery. Our work also helps designers to apply the perception of a restorative environment to the improvement of physical spaces by selecting biophilic design features to alleviate stress

and anxiety. In addition, this study provides evidence of the mental health-promoting benefits of biophilic design in indoor environments, which enrich the theoretical and practical results for the research on the restorative environment of indoor vertical greenery. In addition, there are some research limitations in this study. The sample size is relatively small due to manpower and time constraints, and future studies can further increase the sample size to enhance the predictive power of the model.

5. Conclusions

With the background of social development and an accelerated pace of life, this study focuses on the benefits of passive interaction between people and indoor greenery from a restorative perspective to explore the social potential of indoor vertical greenery. Taking "LONG-PLAN" as an example, this paper uses a questionnaire survey and quantitative analysis based on SPSS to evaluate the impact of indoor vertical greenery on creating a restorative environment. Then we further investigate the relationship between the restorative environmental factors and visual satisfaction of indoor vertical greenery.

The results show that: (1) The respondents have a high score on the restoration of indoor vertical greenery environment; that is, indoor environmental greenery has a positive impact on users' subjective restoration. (2) The three factors of "being away," "fascination and compatibility," and "extent" of environmental restoration have a significant positive correlation with the visual satisfaction of indoor vertical greenery. (3) In the regression analysis between the three factors and the visual satisfaction of indoor vertical greenery, only "fascination and compatibility" shows a significant positive correlation. The correlation between the other two is not significant. Therefore, as an environmental element affecting mental health, vertical greenery plays a positive role in creating a restorative environment. (4) The visual satisfaction of indoor vertical greenery significantly impacts environmental restoration. Therefore, we should focus on the environmental characteristics of "fascination and compatibility" to create a restorative indoor space. It helps attract people's attention by improving the freshness of the architectural landscape environment, which enhances the restorative benefits of the environment and improves the comfort and satisfaction of people's experience in the environment.

The innovation of this study lies in the following aspects: firstly, this paper adopts an experimental method based on the experimental scenario of daily life and the passive interaction between people and indoor green plants as the basis for the environmental behavior experience. This method is different from most of the previous studies that used virtual photos or created a square experiment room for control group experiments, which leads to a more direct and immersive investigation on people's emotions and makes the experimental results more convincing. Secondly, this study uses a quantitative approach to explore the relationship between environmental restorative factors and satisfaction with the visual satisfaction of indoor vertical greenery, which helps to assist in design optimization decisions. In the context of healthy architecture, this study has implications for the design and optimization of indoor landscapes and the design of more psychologically sustainable urban living environments.

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Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data presented in this study are openly available in (Mendeley data) at (10.17632/hhrnpr5hxf.3).

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Appendix A

Questionnaire

Assuming that this house would be your daily living space, rate the following descriptions on a scale of 1 to 5 based on your personal feelings. 1 means completely inconsistent and 5 means completely consistent.

(Note: Please do not take time to deliberate when answering, just go with the flow and answer according to your reaction.)

Table A1. Questionnaire on the restoration benefit and visual satisfaction of LONG-PLAN's indoor vertical greenery.

Items		
	Visual Satisfaction	1( ) 2( ) 3( ) 4( ) 5( )
Being Away	1. It keeps me away from a lot of stress in real life.	1( ) 2( ) 3( ) 4( ) 5( )
	2. It is a lot different from the environment I am exposed to in my daily life.	1( ) 2( ) 3( ) 4( ) 5( )
	3. When I am here, I do not have to ponder over my responsibilities.	1( ) 2( ) 3( ) 4( ) 5( )
	4. Staying here gives me a good break from my daily chores.	1( ) 2( ) 3( ) 4( ) 5( )
Fascination and Compatibility	5. This environment gives me novelty.	1( ) 2( ) 3( ) 4( ) 5( )
	6. I can see, listen, feel and ponder over a lot of things here.	1( ) 2( ) 3( ) 4( ) 5( )
	7. My attention is drawn here.	1( ) 2( ) 3( ) 4( ) 5( )
	8. It makes me feel comfortable here.	1( ) 2( ) 3( ) 4( ) 5( )
	9. Living here, I can do what I like.	1( ) 2( ) 3( ) 4( ) 5( )
	10. I want to stay here longer.	1( ) 2( ) 3( ) 4( ) 5( )
	11. It can evoke my recollection or imagination.	1( ) 2( ) 3( ) 4( ) 5( )
Extent	12. I think this environment is boring.	1( ) 2( ) 3( ) 4( ) 5( )
	13. I think the environment is very monotonous.	1( ) 2( ) 3( ) 4( ) 5( )
	14. I feel like it's chaotic here.	1( ) 2( ) 3( ) 4( ) 5( )
	15. I'm going to feel very upset here.	1( ) 2( ) 3( ) 4( ) 5( )

Table A2. The Chinese version of the Perceived Restoration Scale (PRS).

Items		
Being Away	1. Spending time here gives me a break from the expectations of people.	1( ) 2( ) 3( ) 4( ) 5( ) 6( ) 7( )
	2. It keeps me away from a lot of stress in real life.	1( ) 2( ) 3( ) 4( ) 5( ) 6( ) 7( )
	3. It's a lot different from the environment I'm exposed to in my daily life.	1( ) 2( ) 3( ) 4( ) 5( ) 6( ) 7( )
	4. When I'm here, I don't have to ponder over my responsibilities.	1( ) 2( ) 3( ) 4( ) 5( ) 6( ) 7( )
	5. Staying here gives me a good break from my daily chores.	1( ) 2( ) 3( ) 4( ) 5( ) 6( ) 7( )
Fascination and Compatibility	6. This environment gives me novelty.	1( ) 2( ) 3( ) 4( ) 5( ) 6( ) 7( )
	7. There is a certain commemorative significance here.	1( ) 2( ) 3( ) 4( ) 5( ) 6( ) 7( )
	8. I can see, listen, feel and ponder over a lot of things here.	1( ) 2( ) 3( ) 4( ) 5( ) 6( ) 7( )
	9. Staying here, I often find something unexpected.	1( ) 2( ) 3( ) 4( ) 5( ) 6( ) 7( )
	10. The setting has fascinating qualities.	1( ) 2( ) 3( ) 4( ) 5( ) 6( ) 7( )
	11. My attention is drawn to many interesting things.	1( ) 2( ) 3( ) 4( ) 5( ) 6( ) 7( )
	12. I feel myself integrated here.	1( ) 2( ) 3( ) 4( ) 5( ) 6( ) 7( )
	13. Living here, I can do what I like.	1( ) 2( ) 3( ) 4( ) 5( ) 6( ) 7( )
	14. I want to stay here longer.	1( ) 2( ) 3( ) 4( ) 5( ) 6( ) 7( )

Table A2. *Cont.*

	Items	
Extent	15. I have a sense that I belong here.	1( ) 2( ) 3( ) 4( ) 5( ) 6( ) 7( )
	16. In this environment, I can notice many things with no effort.	1( ) 2( ) 3( ) 4( ) 5( ) 6( ) 7( )
	17. It can evoke my recollection or imagination.	1( ) 2( ) 3( ) 4( ) 5( ) 6( ) 7( )
	18. I think this environment is boring.	1( ) 2( ) 3( ) 4( ) 5( ) 6( ) 7( )
	19. I think the environment is very monotonous.	1( ) 2( ) 3( ) 4( ) 5( ) 6( ) 7( )
	20. There is too much going on.	1( ) 2( ) 3( ) 4( ) 5( ) 6( ) 7( )
	21. I feel like it's chaotic here.	1( ) 2( ) 3( ) 4( ) 5( ) 6( ) 7( )
	22. I'm going to feel very upset here.	1( ) 2( ) 3( ) 4( ) 5( ) 6( ) 7( )

Note: The sections of the blue font (i.e., the referenced item1, 7, 9, 15, 16, and 20) were removed, and the sections of the red font (i.e., the referenced item 10, 11, and 12) were combined or paraphrased.

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