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Layout Design of Building Interior Green Space Based on Psychological Evaluation

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Abstract: With the continuous development of the times, people are facing more and more pressure, which leads to people's mental health status getting worse and worse, and the interior space color design has a certain impact on people's mental health status. In this case, the concept of green design has been paid more and more attention by people, and the concept of green design has gradually penetrated into the industry of interior design. This paper designed the indoor green space layout of the building, analyzed the concept of green building and the principles and contents of indoor green design, and analyzed the impact of indoor green design on people's psychology. By testing different volunteers, it was found that the indoor green space of the building can significantly reduce the negative situation of the occupants, and the positive situation can be significantly improved. Living in the indoor green space of the building can greatly increase the mental health score of the occupants, and the indoor green space of the building can increase the satisfaction of the occupants by 8.9%.

1. Introduction

This is an era of high development. Information technology has become the mainstream of this era. In this era of fierce competition, people's lives are far away from nature. What they see every day are red and green boards that irritate their eyes. People are more and more willing to get close to nature and integrate with nature. Green gradually enters the room, because green can make people feel relaxed, and people who work at home can feel the aura of nature as soon as they look up. Bringing life to the environment at home is important in helping people maintain a healthy mindset.

Reasonable indoor green space layout can increase the utilization rate of space. Samimi P M proposed a framework based on a green space design cost model, using the method of optimizing the indoor environment. Two relative transformation methods were proposed to improve the safety effect of the optimal interior design of the environmental field foundation [1]. Fuertes E understood the application of green plants in indoor environment through experiments, and understood their role in indoor environment, and the application of indoor space [2]. Chan I adopted passive natural lighting design method for the light environment of building interior spaces, adjusted and optimized

the lighting green environment layout and performance indicators of existing building interior spaces, created an excellent quality of light environment in the interior space of the building, and created an efficient and comfortable working and living environment [3]. Patel D M introduced the interior of commercial banks and the role of green concepts, presentation and analysis of interior green design principles and practices, and specific applications in commercial banks in each interior space, and aiming to highlight the green interior design is to create a general environment, and commercial banks are an important part of providing people with a convenient, flexible, healthy and comfortable environment [4]. Nuamah J discussed the important role of indoor plants in modern residential green decoration from five aspects: the purpose and effect of indoor green decoration, plant selection, basic principles, main forms and indoor green decoration design [5]. The above research shows the importance of indoor green space design, but how to design reasonably is still a problem.

Many researchers have analyzed people's inner psychological activities based on psychology. In order to understand the psychological adaptation of landless farmers and measure the impact of changes in their living environment, Abreu M conducted surveys on farmers. The results showed that the land-expropriated farmers have different degrees of psychological problems such as survival crisis, identity confusion, inferiority complex and anxiety caused by social discrimination [6]. Through interviews with empty-nest elderly people, Alam M understood their specific psychological needs and the development of social services, and proposed to improve the social security system, carry out social services for the elderly, contribute to active and healthy aging, and coordinate social development [7]. Based on related research in the field of psychological capital, Sekerazh T N found that the realization of psychological contract and the development of individual psychological capital are of great significance for improving individual and organizational performance [8]. Balanev D Y dynamically analyzed the impact of psychological capital on the individual growth of college students based on data mining technology. Using structural formula modeling, the results showed that the development of college students' psychological capital has a very important impact on their future study and work [9]. Starting from the psychological characteristics of major post-disasters, the performance of victims and the influencing factors of individual psychological crisis response, Mitina L M expounded the application significance of psychological crisis early warning evaluation in post-disaster reconstruction [10]. The above research shows that it is very important to conduct psychological analysis on different groups of people, but how to solve people's psychological problems is a difficult problem.

Building indoor green space can provide people with a comfortable living environment. This paper analyzed the layout design of building indoor green space based on psychology, and found that the indoor layout of green space has a positive impact on people's psychology, which can eliminate negative emotions well, and people are more satisfied with the layout of indoor green space.

2. Indoor Green Space Layout Design

(1)Conceptual analysis of green building

The definition of green building can basically be summarized into many aspects: energy saving, harmony with nature, sustainable development. Green buildings hope to save resources and provide people with a comfortable environment, but the purpose of the three is different. Eco-architecture regards architecture as an integral part of the ecosystem, puts architecture and the environment together, and pays more attention to the relationship between architecture and the environment. Sustainable architecture takes into account not only the present, but also the impact on future generations at a macro level. Green buildings aim to provide people with a comfortable

environment while reducing resource consumption during the building cycle. Compared with sustainable buildings and ecological buildings, green buildings emphasize design from a micro perspective, which is very innovative, as shown in Figure 1.

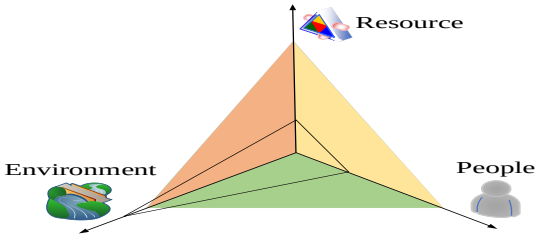


Figure 1. Conceptual analysis of green buildings

(2)Influence of indoor environment on human physiology and psychology

People's emotions are affected by many factors, such as noise, traffic congestion, air pollution, etc. To study the relationship between the internal environment and people's perception, the purpose is to create a comfortable and positive environment. Factors such as temperature, humidity and indoor air quality are also the main factors that affect people's physiological emotions. Indoor color, landscape and size and other factors would affect people's psychological feelings. Reasonable size and unique interior environment design would bring people positive psychological feelings such as happiness and joy. Incorporating green in interior design provides suitable architectural space for occupants, as shown in Figure 2.

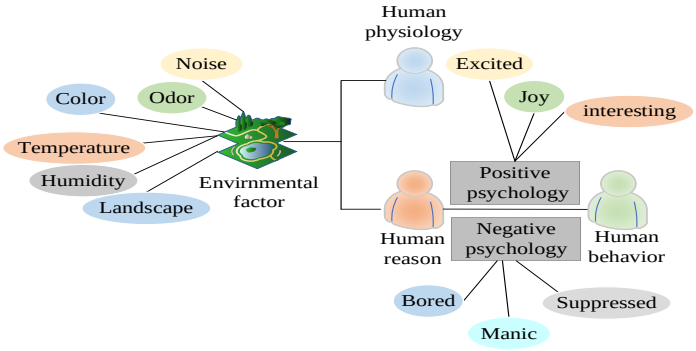


Figure 2. Effects of indoor environment on human physiology and psychology

(3)Indoor scene layout estimation method

It can be divided into outdoor images and indoor images according to the different shooting scenes. In contrast to the ever-changing exterior surfaces, interior scenes are often constrained by the Manhattan spatial premise, which can be defined by structural evaluation, retrieving the layout of the room as much as possible from intermittent images inside the view [11]. The so-called layout is to accurately divide the various walls in the interior image. Figure 3 is a flowchart of a common solution for indoor event estimation.

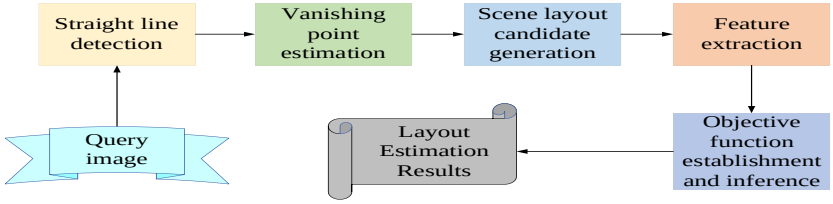


Figure 3.Indoor scene layout estimation method

As an important front-end unit for solving many visual perception problems such as 3D scene reconstruction and target position estimation, indoor scene layout has great research value. Visual

grounding analysis selects the candidate that best matches the ground truth by feature training on various candidate grounding sets [12]. The generation of candidate objects is implemented in two steps. First, a regular algorithm is used to find all the line segments in the image and divide them into three orthogonal intersections according to certain criteria. Then, the light rays passing through the empty space are randomly selected, and each pair of rays constrains the position and size of a different wall, thereby creating various candidate box structures. According to the general structure of the interior space design scheme, it can be divided into multiple tasks.

(4)Principles and contents of interior green design

Green interior design is the rational use of natural colors and natural materials in the indoor environment, saving and considering the use of natural materials and energy. The interior design of the living room based on the principles of economy, practicality and greenness makes people live happily, safely and comfortably at home, and makes people rest easily and comfortably during the working day, which is conducive to the pleasure of human spirit. The basic principle is shown in Figure 4.

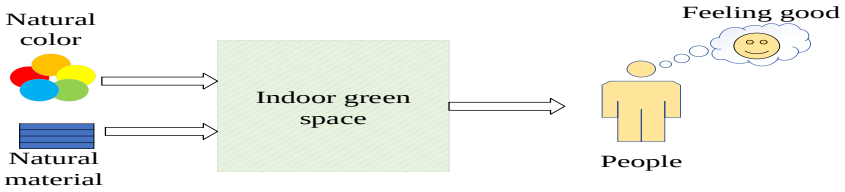


Figure 4.Principles of green interior design

The main content of interior green design is that the interior design of the space should make full use of sunlight, ventilation, water, materials and various natural resources and energy sources, and build a healthy and environmentally friendly ecological environment in accordance with the concept of sustainable development; the materials used indoors should pay attention to non-toxic, safe, green and environmentally friendly materials; when renovating a house, there is less abuse and waste.

3. Indoor Building Layout Algorithm Model

(1)Layout estimation modeling for optimal selection of layout candidates

The green layout of architectural interior space is to select the best layout candidate from multiple interior layout options. Usually, the best option for interior space design is the one that is most similar to the basic definition of the corresponding image [13-14]. Given a training data set consisting of the internal mapping of evaluation point $\{m_1, m_2, m_3, ..., m_y\} \in M$ and the corresponding target reference point $\{n_1, n_2, n_3, ..., n_y\} \in N$, the mapping relationship $f : M \to N$ between the input point *M* and any intelligent output point *N* is learned from the training data item (m_i, n_i).

Given an input image m_i, each of the generated first candidates can be evaluated by designing a function *f* to obtain the corresponding score. The candidate whose n_i has the highest similarity to the reference frame definition should get the highest score. Based on the above assumptions, the objective function can be obtained, and the specific mathematical expression is shown in Formula 1:

$$n^* = \arg\max_n f(m, n, w) \tag{1}$$

Among them, *w* represents the parameter vector; n^* represents the final result set; *n* represents the existing layout scheme. The function *f* can be regarded as a matching function that measures the degree of matching between (m, n).

Assuming that the input *m* and the output *n* can be expressed as $\psi(m,n)$ in the form of a unit combination, then *f* is linear, as expressed in Formula 2.

$$f(m,n,w) = w^T \psi(m,n) \tag{2}$$

The relationship between image *m* and random variable *n* represented by features can be considered as a graphical model. The model shows that the position of each random variable by itself is not an accurate predictor, and it is always necessary to include other variables that exist in near isolation, and the positions of the variables are considered together. Therefore, the above-mentioned inference task is called organizational prediction and is usually determined by an organizational learning model that exploits the relationship between different outcomes in a production environment to better utilize a known training dataset [15].

Under the assumption of Formula 2, the problem of determining the matching relationship f is transformed into the problem of determining the parameter *w*, and the determination of the parameter *w* can be transformed into the following structural problem, which is mainly represented by Formula 3.

$$\begin{aligned} &\min_{w,\xi C} \frac{1}{2}\|w\|^2 + C\sum_i \xi_i \\ &s.t. \quad \forall i : \xi_i \geq 0, and \\ &\forall i, \forall n \in N \setminus n_i : w^T \psi(m_i, n_i) - w^T \psi(m_i, y) \geq \Delta(n_i n) - \xi_i \end{aligned} \tag{3}$$

Among them, ξ_i represents the lazy variable; $\Delta(n_i, n)$ represents the loss function, which is used to measure the distance between the two parameters; *C* represents the scaling constant $\psi(m_i, n_i)$; (m_i, n_i) represents the feature generated by extracting features from *C* according to the image.

Loss function $\Delta(n_i, n)$ mainly considers three aspects. For *m* interior scenes, its basic definition is expressed as:

$$F = \{F_1, F_2, F_3, F_4, F_5\} \tag{4}$$

Among them, F_1 represents the ground; F_2 represents the middle wall; F_3 represents the right wall; F_4 represents the left wall; F_5 represents the ceiling. Any generated candidate configuration is represented as $F = \{F_{i1}, F_{i2}, F_{i3}, F_{i4}, F_{i5}\}$, then the specific function definition loss is given by Formula 4:

$$\Delta(n_i, n) = \Delta_t(n_i, n) + \Delta_c(n_i, n) + \Delta_p(n_i, n) \tag{5}$$

Δ_t is used to measure the proportion difference of the corresponding area in the entire image, and $\Delta_t(n_i, n)$ is defined as shown in Formula 6:

$$\Delta_t(n_i,n)=\sum_{k=1}^{5}\begin{cases}1\\ \dfrac{\left\|Area(F_{ik})-Area(F_k)\right\|}{Area(image)}\\ 0\end{cases} \tag{6}$$

Among them, F_k represents the kth local area surface in the first candidate reference definition, and $Area(\cdot)$ represents the area of the predefined area, which can be transformed to calculate the total number of pixels in the defined area. In the corresponding configuration, if regions F_{ik} and F_k are missing, Δ_t is considered to be 0. If both are present, the difference in the proportion of pixels that the two occupy in the entire image is calculated, but if the group is missing, a constant loss value is used as a penalty for inconsistency in its regional faces.

Δ_c is used to measure the standard deviation of the corresponding area center, and the definition of $\Delta_c(n_i,n)$ is shown in Formula 7:

$$\Delta_c(n_i,n)=\sum_{k=1}^{5}\begin{cases}1\\ \left\|c_{ik}-c_k\right\|\\ 0\end{cases} \tag{7}$$

Among them, c_{ik} and c_k represent the centroid coordinates of the area centered on F_{ik} and F_k, respectively. Since F_k is the set of coordinate points around the surface, the calculated centroid coordinates can be converted into the sum of the coordinate points. In the corresponding basis set, if both vertices F_{ik} and F_k are missing, then obviously Δ_c is 0. If both are present, the difference in motion of the two centroids is calculated and set using the diagonal length of the image.

Δ_p is used to measure the percentage difference in allocation points between regions, and $\Delta_p(n_i,n)$ is defined as Formula 8:

$$\Delta_p(n_i,n)=\sum_{k=1}^{5}\sum_{l=1}^{5}\begin{cases}1-\dfrac{Area(F_{il}\cap F_k)}{Area(F_{il}\cup F_k)}, l=k\\ \dfrac{Area(F_{il}\cap F_k)}{Area(F_{il}\cup F_k)}, l\neq k\end{cases} \tag{8}$$

The first two loss functions are solved for a specific $\{F_{ik},F_k\}$-pair, and only the loss between the first candidate and the kth local surface in the boundary definition is calculated without computing the loss between the first candidate and the first local surface in the boundary definition.

(2)Spatial normal vector and geometric depth information extraction

For the geometric depth information extraction task, a loss function is defined to compare the difference between the predicted depth map and the ground truth [16]. The specific mathematical expression is given by Formula 9:

$$L_{depth}(D,D^*)=\frac{1}{x}\sum_i d_i^2-\frac{1}{2x^2}(\sum_i d_i)^2+\frac{1}{x}\sum_i[(\nabla_m d_i)^2+(\nabla_n d_i)^2] \tag{9}$$

Among them, d represents the difference between the predicted depth and the reference depth and $d = D - D^*$; i represents a pixel of the image; x represents the sum of the number of pixels in the image. $\nabla_m d_i$ and $\nabla_n d_i$ represent the depth change rates between pixels in the horizontal and numerical directions, respectively.

The mathematical expression of the loss function is:

$$L_{normals}(X, X^*) = -\frac{1}{x}\sum_i X_i \cdot X_i^* = -\frac{1}{x} X \cdot X^* \tag{10}$$

Among them, X and X^* represent the predicted normal map and the threshold labeled normal map, respectively. Since the normal values are experimentally correct, the loss function can calculate the deviation of all pixels as an inner product.

(3)Geometric integration efficiently extracts regional features

Each initial candidate must be mapped to a feature region, that is, according to the configuration of the initial candidate and the original image, fixed-size features are extracted to represent the configuration of the candidate [17-18]. Fixed-size components are extracted region-by-region on a $\psi(m,n)$-region-by-region basis, and are done by partitioning regions consistently.

$$w^T\psi(m,n) = \sum_{\alpha\in F} w_{c,\alpha}^T \Psi_{c,\alpha}(m,n_\alpha) + \sum_{\alpha\in F} w_{g,\alpha}^T \Psi_{g,\alpha}(m,n_\alpha) + \sum_{\alpha\in F} w_{x,\alpha}^T \Psi_{x,\alpha}(m,n_\alpha) + \sum_{\alpha\in F} w_{d,\alpha}^T \Psi_{d,\alpha}(m,n_\alpha) + \sum_{\alpha\in F} w_{y,\alpha}^T \Psi_{y,\alpha}(m,n_\alpha) + \sum_{\alpha\in F} w_{d,\alpha}^T \Psi_{d,\alpha}(m,n_\alpha) \tag{11}$$

The subscripts c, g, x, and d represent line segment features, geometric positions, normal vectors, and depth features, respectively, and y represents the room geometry evaluation structure parameterized by the angle of loss of light.

Since the geometric model is only a complete two-dimensional set, in order to calculate the local features or the overall probability of the space produced by the connecting rays separated by two different air points, it is necessary to calculate a linear function through multiple sets [19]. Since each grouping is based on only two rays, the above-mentioned higher-order forces can be decomposed into combinations of pairwise factors [20].

Taking the left wall, right wall, ground, and ceiling as examples to decompose the characteristic potential energy, the decomposition formula is as follows:

$$\psi_{.,F_4}(m,n_\alpha) = \psi_{.,\{1,2,3\}}(m,n_1,n_2,n_3) = A_{.,\{1,3\}}(m,n_1,n_3) - A_{.,\{2,3\}}(m,n_2,n_3) \tag{12}$$

$$\psi_{.,F_3}(m,n_\alpha) = \psi_{.,\{1,2,4\}}(m,n_1,n_2,n_4) = A_{.,\{1,4\}}(m,n_1,n_4) - A_{.,\{2,4\}}(m,n_2,n_4) \tag{13}$$

$$\psi_{.,F_1}(m,n_\alpha) = \psi_{.,\{1,3,4\}}(m,n_1,n_3,n_4) = A_{.,\{1,3\}}(m,n_1,n_3) - A_{.,\{1,4\}}(m,n_1,n_4) \tag{14}$$

$$\psi_{.,F_5}(m,n_\alpha) = \psi_{.,\{2,3,4\}}(m,n_2,n_3,n_4) = A_{.,\{2,3\}}(m,n_2,n_3) - A_{.,\{2,4\}}(m,n_2,n_4) \tag{15}$$

Among them, A represents the set of features calculated to synthesize the features of a specific surface F_i, and a similar decomposition method can be used for all surfaces. The central wall of this region must be jointly determined by the four parameters $\{n_1,n_2,n_3,n_4\}$. The central wall force involves a linear combination of multiple loads, but can also be decomposed into a cumulative form of increasing force. The specific mathematical expression is shown in Formula 16.

$$\psi_{.,F_2} = \psi(m) - \psi_{.,F_3} - \psi_{.,F_4} - \psi_{.,F_1} - \psi_{.,F_5} \tag{16}$$

$\psi(m)$ represents the overall potential energy, which is a fixed value that does not depend on any variable and calculates the sum of the features of the entire image, and each of the potential energy $\psi_{.,F_i}$ can be decomposed into a second energy level form. So far, except for the mid-wall region where 4 variables need to be parameterized together, the rest of the surface only needs 3 variables (n_i, n_j, n_k). $i, j, k \in \{1,...,4\}$ and $i \neq j \neq k \neq i$. Therefore, in principle, the levels of these potentials are the third and fourth orders, respectively.

4. Psychological Impact of Indoor Green Space on People

In order to detect the psychological impact of indoor green space on people, 10 volunteers were randomly selected to participate in this experimental test and divided into groups of 5 for the experimental test. Among them, one group of volunteers lived in the indoor space of traditional buildings, and the second group of volunteers lived in the indoor green space of the building. The test time was 8 weeks to observe how living in different indoor spaces would affect people's psychology. During the experiment, the volunteers were tested for negative situation, positive situation, mental health score, and residential satisfaction test, to observe the influence of indoor green space on the psychological changes of the residents, and to record the difference between the psychological changes of the two groups of volunteers. The specific data of the group volunteers are shown in Table 1.

Table 1.Volunteer specific data

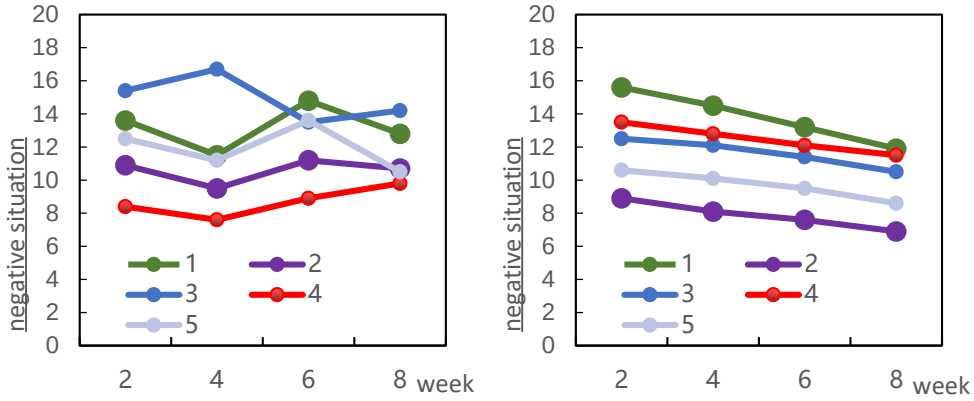
	volunteer	age	gender
Group 1	1	29	male
	2	35	female
	3	39	female
	4	26	male
	5	41	female
Group 2	1	45	male
	2	42	female
	3	38	male
	4	37	female
	5	26	male

(1)Negative situation test

The more negative people are, the more likely they are to develop mental illness and the less conducive to the development of mental health. Two groups of volunteers were tested for negative conditions, and the experimental results were recorded every two weeks to observe how the indoor green space of the building had different effects on the negative conditions of the volunteers compared with the indoor space of traditional buildings. The experimental results were recorded and analyzed, and the experimental results are shown in Figure 5.

In Figure 5, Figure 5A is the test results of the negative situation of volunteers in the first group, and Figure 5B is the test results of the negative situation of the volunteers in the two groups. Since the psychological states of different volunteers are different, the negative situations of different volunteers would also different. Among them, 5 volunteers in group 1 lived in the indoor space of traditional buildings. During the 8 weeks of the test, the negative situation of the volunteers was unstable, sometimes rising and sometimes falling. In the test result graph of the 2 groups of volunteers, the first volunteer had the highest negative situation, and the second volunteer had the lowest negative situation, but the negative situation of all volunteers decreased steadily. To sum up,

the traditional building interior space has no obvious impact on the negative situation of the occupants, while the indoor green space of the building can significantly reduce the negative situation of the occupants.

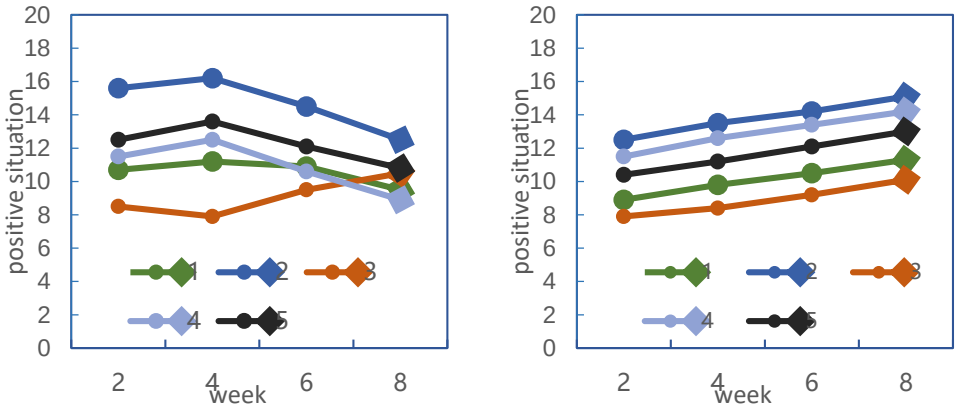


A.1 group volunteer test results B. 2 group volunteer test results

Figure 5.Negative situation test results

(2)Positive situation test

Positive situation refers to people's positive emotions. The higher people's situation is, the better their psychological state is. The positive situation test was conducted on two groups of volunteers to observe the difference in the positive situation of volunteers in different living environments. The experimental results were recorded and analyzed, and the specific results are shown in Figure 6.



A.1 group volunteer test results B. 2 group volunteer test results

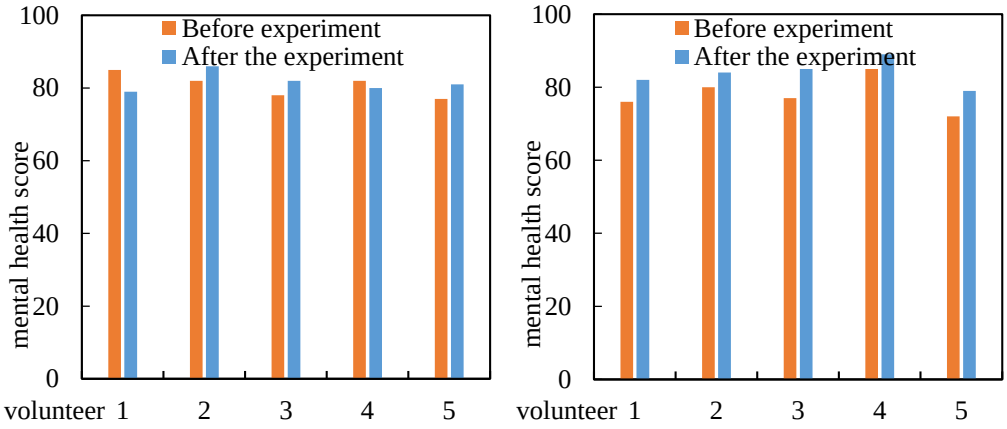
Figure 6.Positive situation test

In Figure 6, Figure 6A is the test result of positive situation of volunteers in 1 group, and Figure 6B is the test result of positive situation of volunteers in 2 groups. Among them, it can be seen from the test results of the positive situation of volunteers in group 1 that the positive situation of volunteer 1, volunteer 2, volunteer 4 and volunteer 5 increased in the 4th week, and the positive conditions continued to decline in weeks 6 and 8, and volunteer 3's positives declined at week 4 and continued to rise thereafter. The positive situation of volunteers in both groups increased steadily, with no sign of decline, among which the positive situation of volunteer 2 was the highest, and the positive situation of volunteer 3 was the lowest.

(3)Mental health score test

The two groups of volunteers were tested for mental health score. The test method was to fill in the mental health score test paper, with a full score of 100 points. The test was conducted once

before and after the test, and the test results were recorded and analyzed. The results are shown in Figure 7.



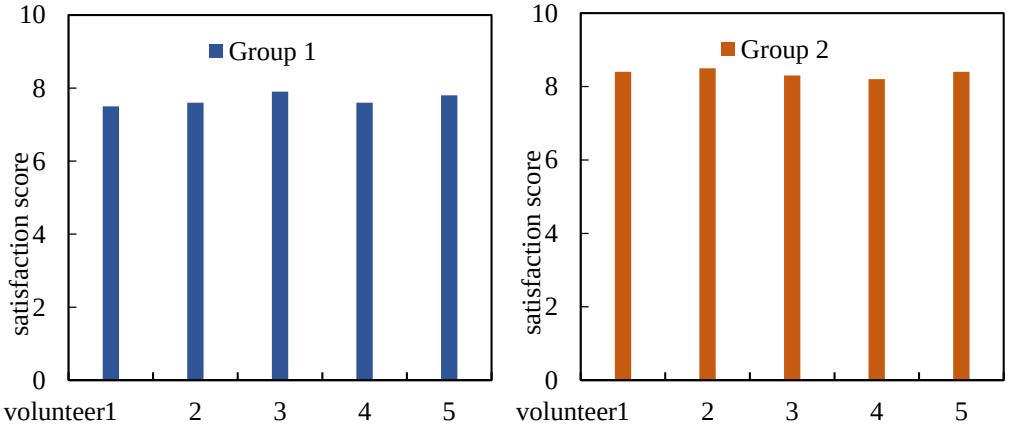
A.1 group volunteer test results B. 2 group volunteer test results

Figure 7.Mental health score test

In Figure 7, Figure 7A is the test result of mental health score of 1 group of volunteers, and Figure 7B is the test result of mental health score of 2 groups of volunteers. Among them, the mental health scores of volunteers in group 1 increased and decreased; the mental health score of volunteer 1 decreased; the mental health score of volunteer 2 increased; the mental health score of volunteer 3 increased; the mental health score of volunteer 4 fell; the mental health score of volunteer 5 rose. The mental health scores of volunteers in both groups increased. Among them, volunteer 4 had the highest mental health score and volunteer 5 had the lowest psychological lecture score. To sum up, the mental health of volunteers living in the indoor green space of the building has been improved, and the indoor green space of the building can keep the occupants in a good psychological state.

(4)Residential satisfaction score test

The more comfortable the living environment, the higher the satisfaction of the occupants. The two groups of volunteers were tested for satisfaction. After the scoring, the experimental results were recorded and analyzed to observe the difference between the satisfaction scores of the traditional building interior space and the building interior green space. The results are shown in Figure 8.



A.1 group volunteer test results B. 2 group volunteer test results

Figure 8. Satisfaction score test

In Figure 8, Figure 8A shows the test results of living satisfaction of group 1 volunteers, and Figure 8B shows the test results of living satisfaction of group 2 volunteers. Among them, the satisfaction score of volunteer 1 in group 1 was 7.5; the satisfaction score of volunteer 2 was 7.6; the satisfaction score of volunteer 3 was 7.9; the satisfaction score of volunteer 4 was 7.6; the satisfaction score of volunteer 5 was 7.8. The average satisfaction score of volunteers in group 1 was 7.68. The satisfaction score of volunteer 1 in group 2 was 8.4; the satisfaction score of volunteer 2 was 8.5; the satisfaction score of volunteer 3 was 8.3; the satisfaction score of volunteer 4 was 8.2; the satisfaction score of volunteer 5 was 8.4. The average satisfaction score of volunteers in group 2 was 8.36. To sum up, the satisfaction scores of volunteers in the two groups were higher than those in the first group, and the indoor green space of the building could increase the satisfaction of occupants by 8.9%.

5. Conclusions

With the continuous development of the times, people's life pressure is increasing, and the psychological state is not enough, and the psychological state is closely related to the living environment. This paper proposed the indoor green space of the building, designed the layout of the indoor green space of the building, and described the principle and demand of the indoor green space of the building. Finally, by letting different volunteers live in the indoor green space, it was found that the indoor green space can reduce the negative emotions of the volunteers, improve the positive emotions of the volunteers, and stabilize the mental health of the volunteers. Compared with the traditional building interior space, the building interior green space is more popular and loved by people.

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