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One Nature-Based Solution to Get Attention Restored: Exploring Perceived Biodiversity's Contributions by Empirical Research in Urban Parks

Research Paper

One Nature-Based Solution to Get Attention Restored: Exploring Perceived Biodiversity's Contributions by Empirical Research in Urban Parks

Yanhong MA, School of Architecture and Fine Art, Dalian University of Technology, Dalian, China

Xi CHEN*, School of Architecture and Fine Art, Dalian University of Technology, Dalian, China

★Corresponding Author, E-mail: cx_jiayou@163.com

Abstract

Biodiversity design methods have been becoming the hot spots in the field of responding to public health threats by nature-based solutions. At present, compared to measured biodiversity, researches on perceived biodiversity which can directly affect the psychology of landscape experiencers are still scarce. Based on the scale design and questionnaire survey, this study explores the causal relationship between perceived biodiversity and attention restoration. The results show that: 1) there is a significant positive correlation between perceived biodiversity and attention restoration; 2) for the four selected categories of perceptual biodiversity, birds and flowers have a great effect on perceived biodiversity promoting attention restoration, while insects and trees have a big one; 3) rare species diversity, species diversity, tactile diversity and olfactory diversity have the greatest influence on the perceived biodiversity of birds, insects, trees and flowers, respectively; 4) The effect of measured biodiversity or park area on attention restoration does not show the correlation trend that "the higher the actual biodiversity or the larger the park area, the more significant the restoration effect": the attention restoration efficiency of parks with high measured biodiversity or large area might be weaker than parks with low measured biodiversity or small area.

Keywords

Nature-based solution, Perceived biodiversity, Restoring attention, Causal relationship, Urban parks

1. Introduction

Biodiversity can provide important cultural ecosystem services in stress relief, positive emotion generation, attention restoration, etc. In recent years, the analysis of the causal path of biodiversity affecting human mental health and the use of biodiversity design methods to promote the construction of healthy cities have become increasingly popular, and have rapidly developed into one of the hot spots in the research field of responding to public health threats by nature-based solutions (Li, 2020; Methorst et al., 2021; Parris et al., 2018).

From the current research progress, on the one hand, in many analyses on the relationship between nature and human health, biodiversity is usually used as a secondary indicator to describe the naturalization degree, category and quality of green space, but there is still a lack of special research on its impact on mental health (Birch et al., 2020; Foo, 2016; Marselle et al., 2019). On the other hand, in the few studies that have been carried out on the impact of biodiversity on mental health, biodiversity is still

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characterized by a professional ecological concept - measured biodiversity (Harvey et al., 2020; Scartazza et al., 2020; Young et al., 2020). The perceived biodiversity, which is closely related to the personal perception of landscape and can have a direct impact on the psychology of landscape experiencers, has not been considered.

Directed attention is a limited resource for people to deal with their daily work and study. At present, the fast-paced urban life and the highly heterogeneous and complex urban environment lead to the excessive consumption of Directed attention and mental fatigue of urban residents, which continuously induces a variety of mental health problems such as depression, reduced life satisfaction, cognitive load and increased pressure. Many research practices based on the attention restoration theory (ART) with the theme of "contact with the natural environment is conducive to mental health" have proved that the identification of restorative environmental characteristics measured by directed attention restoration is a reliable method to analyse the impact of the environment on mental health (Li et al., 2020; Moran, 2019; Ratcliffe et al., 2013).

Under the background of high-density and high-intensity urban space utilization, urban parks play an important role in urban biodiversity protection. At the same time, as an important public place to provide the public with a recreational environment, urban parks are often the only way for urban residents to access the nature and interact with the biodiversity environment, and play an important supporting role for urban residents to obtain relevant health benefits and well-being from the biodiverse environment.

Based on the field survey data in urban parks, Chongqing, China, this study establishes a causal relationship model for perceived biodiversity promoting attention restoration, and explores the impact relationship and recovery efficacy, to provide a reference for subsequent related research.

2. Key concepts

2.1. Perceived biodiversity

There is a clear inconsistency between the measured biodiversity and the perceived biodiversity. Compared with the spatiotemporal uniqueness of the former in terms of quantity and structure, the latter shows obvious differences due to the differences in the characteristics of different species and their perceived locations (for example, the possibility of microbial species and nocturnal species being perceived by landscape experiencers is low), as well as the differences in the prior knowledge, cognitive level and aesthetic preference of landscape experiencers. That is, in the context of affecting mental health, for ordinary landscape visitors, the understanding of biodiversity is mainly based on the perceptually distinguishable landscape features. Therefore, in the correlation analysis of objective environment affecting subjective psychological feelings, perceived biodiversity is more important than measured biodiversity, and is more suitable as a biodiversity environmental variable affecting mental health.

2.2. Mechanism of attention restoration

Human attention is divided into directed attention and undirected attention. From the perspective of environmental psychology, the input of directed attention often requires more cognitive effort and is prone to cognitive fatigue; in contrast, undirected attention does not consume too much energy. Thus, the recovery of directed attention tends to occur when undirected attention is engaged (LI et al., 2020; Liu and Li, 2020).

Landscape environments that can restore directed attention tend to have four characteristics—being away, fascination, coherence, and compatibility. The more variety and intensity of these characteristics, the more resilient they are. Among them, being away means that people can temporarily break free from "being forced to focus on something that is not intrinsically attractive in order to achieve certain goals"; fascination means that a place can provide environmental stimuli that attract people's unconscious attention; coherence means If these stimuli are rich enough and organized in a coherent way, the perceptual experience of fascination in the environment can be sustainable. If the quality of the environment has a high degree of conformity with people's goals, tendencies and psychological expectations, it indicates that the environment has good compatibility (Kaplan, 1995; LI et al., 2020; Nghiem et al., 2021; Peschardt and Stigsdotter, 2013).

3. Research methods

3.1. Case area selection

The urban environment of Chongqing is characterized by high density, high heterogeneity and high complexity. It brings a large cognitive load to the multi-dimensional senses such as sight and hearing, which leads to increased pressure. At the same time, the probability of inducing generalized anxiety, attention fatigue and mood disorder is also higher. In addition, due to the influence of mountain topography, the vertical temperature and humidity gradient in Chongqing changes significantly, the composition of biological communities is relatively complex, and the biodiversity resources are very rich. Therefore, this study takes Chongqing as a case city, and uses the "urban parks" in the city, which are most in contact with natural creatures, as a space carrier to explore the impact of biodiversity on attention restoration, which has strong representativeness and application value.

3.2. Research hypothesis

Although species such as squirrels and frogs can be occasionally seen in a park or common in some special parks, they are not universal for general urban parks. Therefore, based on the characteristics of the most common species categories in the general urban parks in the case area, the study divides the perceived biodiversity into four categories: bird perceived biodiversity, insect perceived biodiversity, tree perceived biodiversity and flower perceived biodiversity. The following research hypotheses are proposed accordingly:

> H1： Bird perceived biodiversity has a significant positive effect on attention restoration;
> H2： Insect perceived biodiversity has a significant positive effect on attention restoration;
> H3： Tree perceived biodiversity has a significant positive effect on attention restoration;
> H4： Flower perceived biodiversity has a significant positive effect on attention restoration.

3.3. Relational modelling

3.3.1 Variable setting

(1) The demographic characteristics of the respondents are explained with five categories of information, including gender, age, education level, and average monthly income, and were set as the demographic characteristics variables of the control variables.

(2) The plant community is the main body of the biological environment and the habitat background of the urban park. The park maintenance and control unit have a relatively complete grasp of the relevant biodiversity information. Therefore, the number of species of trees, shrubs and grasses is selected to

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characterize the actual biodiversity of the park and set it as the actual biodiversity variable of the control variables. At the same time, the size of the site is related to the biological capacity and biodiversity abundance in the site, and can have an important impact on the spatial perception experience. Therefore, the park area is set as the spatial size variable of the control variables to observe the corresponding impact caused by the difference of the park areas.

(3) Based on the above analysis, "B attention restoration" was set as the latent variable of the dependent variable, and "B1 being away", "B2 fascination", "B3 coherence" and "B4 Compatibility " were used as the Observed variables to characterize the latent variable. According to the general "Perceived Restoration Scale" (PRS) (Payne and Guastavino, 2018; Peschardt and Stigsdotter, 2013; Nghiem et al., 2021), which measures attention restoration, the "Park Perceived Biodiversity Restoration Scale" was designed to measure the above Observed variables (Table 1). At the same time, "A1 bird perceived biodiversity ", "A2 insect perceived biodiversity", "A3 tree perceived biodiversity" and "A4 flower perceived biodiversity" were set as four level-1 independent variables corresponding to the dependent variable. Based on previous literature (Cameron et al., 2020; Li et al., 2019; Delplanque et al., 2019), in June 2020, pre-investigation and semi-structured interviews were carried out in the urban parks of the main urban area of Chongqing in the form of questionnaires (a total of 124 valid questionnaires were collected); according to 6 biodiversity characteristics For the frequency analysis of the attractiveness of respondents, the second-level characterization factors (observed variables) corresponding to the first-level independent variables were selected (Table 2). According to the frequency analysis of the attractiveness of the 6 biodiversity characteristics to the respondents, the second-level representation factors (observed variables) corresponding to the first-level independent variables were selected (Table 2). The overall variable setting is shown in Table 3.

Table 1. Recovery Scale of park perceived biodiversity.

Four characteristics	Park Perceived Biodiversity Restoration Scale
Being Away	1. Spending time here gives me a break from my day-to-day routine. 2. This place is a refuge from unwanted distractions. 3. In this place I don't think about things I have to do. 4. In this place nobody tells me what to do or think.
Fascination	5. This place is fascinating. 6. In this place many interesting things happen. 7. This place awakens my curiosity. 8. In this place I don't get bored.
coherence	9. In this place everything belongs here and is just where it should be. 10. This place is big enough to be explored in many directions. 11. In this place there are lots of things to discover. 12. There is a clear order in the physical arrangement of this place.
Compatibility	13. Being here fits with my personal inclinations. 14. In this place I rapidly adapt to the setting. 15. In this place I am free to play, run and think. 16. In this place I can relax mentally and physically.

Table 2. Selection of 2-level characterization factors of independent variables.

Biological category	Pre-survey design	Report frequency （n=248）	Selection of second-Level characterization factors

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A1 Bird perceived biodiversity	Under each biological category, which of the following two biological diversity characteristics can attract your attention and bring you the most fun?	80 (Species diversity) 74 (Sound diversity) 89 (Rare species diversity) 5 (Color diversity)	A1a Species diversity A1b Sound diversity A1c Rare species diversity
A2 Insect perceived biodiversity		90 (Species diversity) 76 (Sound diversity) 71 (Rare species diversity) 7 (Color diversity) 4 (Tactile diversity)	A2a Species diversity A2b Sound diversity A2c Rare species diversity
A3 Tree perceived biodiversity	1. Species diversity 2. Rare species diversity 3. Sound diversity 4. Color diversity 5. Olfactory diversity 6. Tactile diversity	63 (Species diversity) 58 (Color diversity) 68 (Tactile diversity) 54 (Rare species diversity) 5 (Olfactory diversity)	A3a Species diversity A3b Color diversity A3c Tactile diversity A3d Rare species diversity
A4 Flower perceived biodiversity		54 (Species diversity) 66 (Color diversity) 75 (Olfactory diversity) 46 (Rare species diversity) 7 (Tactile diversity)	A4a Species diversity A4b Color diversity A4c Olfactory diversity A4d Rare species diversity

Table 3. Variable setting.

Independent variable		Dependent variable	
Latent variable	Observed variables	Latent variable	Observed variables
A1 Bird perceived biodiversity	A1a Species diversity A1b Sound diversity A1c Rare species diversity	B Attention restoration	B1 Being Away
A2 Insect perceived biodiversity	A2a Species diversity A2b Sound diversity A2c Rare species diversity		B2 Fascination
A3 Tree perceived biodiversity	A3a Species diversity A3b Color diversity A3c Tactile diversity A3d Rare species diversity		B3 Coherence
A4 Flower perceived biodiversity	A4a Species diversity A4b Color diversity A4c Olfactory diversity A4d Rare species diversity		B4 Compatibility

3.3.2 Variable measurement

This study investigates the basic situation of the demographic characteristics of the respondents in the form of objective multiple-choice questions; The actual biodiversity and spatial size of the investigation area were characterized by the number of trees, shrubs and grasses and the park area. At the same time, through the form of self-report questionnaire, the information of observed variables corresponding to the perceived biodiversity and attention restoration of the park environment was collected. The questionnaire uses Likert's 5-level scale to evaluate the observed variables. The interviewees scored the relevant descriptions according to their subjective judgment and real thoughts ("1" means very disagree; "2" means relatively disagree; "3" means uncertain; "4" means relatively agree; "5" means very agree).

3.3.3 Analytical method

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Structural equation model (SEM) was used to analyse the causal relationship between perceived biodiversity and attention restoration.

Compared with traditional regression models that do not allow measurement errors in independent variables, SEM can not only deal with the relationship between observed variables and latent variables and each latent variable, but also consider error variables, which can solve the problem of independent variables in this study (A1, A2, A3, A4, B) cannot be directly measured and there are measurement errors. At the same time, SEM can also measure the direct or indirect impact of pre-set causal relationships, and clearly analyse the role of individual indicator on the overall and the complex relationship between individual indicators. Based on this, SEM was used to theoretically model the causal relationship between perceived biodiversity and attention restoration (Fig. 1), and then the model was validated and computationally analysed.
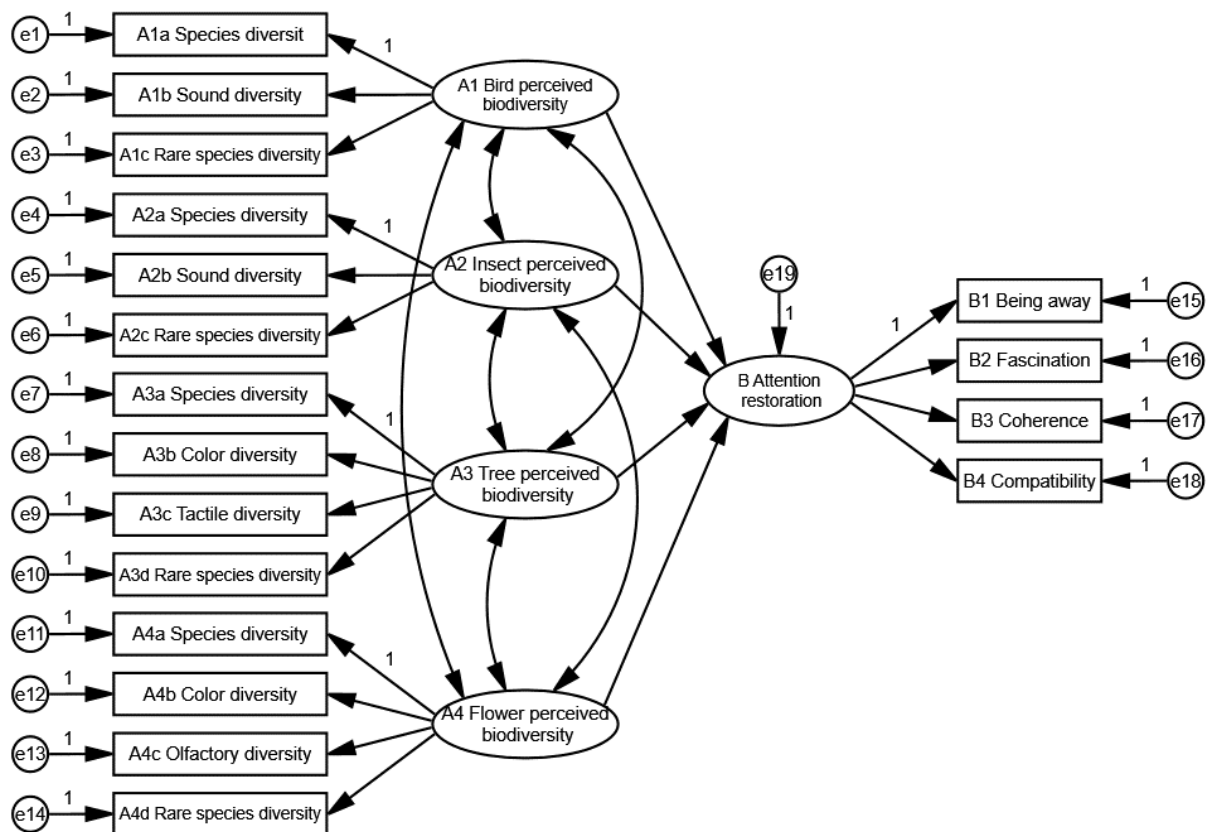

Figure 1. Theoretical model of structural equation.

3.4. Data collection

In order to highlight the representativeness of the random interview samples to the greatest extent, combined with the previous field survey and the suggestions of ecological experts, among the parks in the main urban area of Chongqing where the total amount of tree, shrub and grass species data can be obtained, Shaping Park, Eling Park, Nanshan Botanical Garden, Zhaomushan Forest Park and Caiyun Lake Wetland Park with high biodiversity abundance, large resident flow, wide service area coverage and large scale were selected to carry out the survey. The official investigation date is the holiday from September

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to October 2020. The number species of trees, shrubs and grasses used to characterize the actual biodiversity of the park and the area data used to describe the size of the survey area were obtained from the park management department (Table 4). The demographic characteristics of respondents and their environmental perception biodiversity and attention restoration information were collected in the form of random questionnaires: To ensure the rationality of the sample, the number of questionnaires in each park was controlled to about 150, and finally a total of questionnaires was collected. According to the completeness and quality of the questionnaires, 49 invalid questionnaires were excluded, and a total of 678 valid questionnaires were collected. The effective recovery rate of the questionnaires was 93.26%. The statistical results of demographic characteristics show that the proportion of male and female respondents is relatively average, the distribution of age levels is reasonable, the coverage of social and economic background is wide, and the overall sample structure is reasonable and has a good representativeness (Table 5).

Table 4. Number of species of trees, shrubs and grasses and area of the park. Source: Park Management Department.

Park name	Number of species of trees, shrubs and grasses (approximate)	Park area (ha)
Shaping Park	890	17.20
Eling Park	830	6.63
Nanshan Botanical Garden	250,0	551.00
Zhaomushan Forest Park	113,0	286.67
Caiyun Lake Wetland Park	680	107.07

Table 5. Demographic and statistical characteristics of valid questionnaires

Item	category	Number of interviewee	Proportion (%)
Gender	male	312	46
	female	366	54
Age	Under 18 years old	95	14
	18-30 years old	142	21
	31-45 years old	210	31
	46-60 years old	163	24
	Over 60 years old	68	10
Educational level	Junior high school and below	88	13
	High school	244	36
	Undergraduate	237	35
	Postgraduate	109	16
Average monthly income	None	149	22
	Within 1000 yuan	48	7
	1000-3000 yuan	95	14
	3000-5000 yuan	223	33

4. Model evaluation and results

4.1. Model reliability and validity analysis

4.1.1 Reliability Analysis

The study uses the Likert scale to measure the observed variables, so it is suitable to use the Cronbach's α coefficient to analyse the reliability of the questionnaire. The reliability test analysis using SPSS 24.0

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shows that: the overall Cronbach's α value of the questionnaire is 0.917, which is an ideal reliability; the Cronbach's α values corresponding to the five latent variables of A1 bird perceived biodiversity, A2 insect perceived biodiversity, A3 tree perceived biodiversity, A4 flower perceived biodiversity, and B attention restoration are 0.838, 0.882, 0.922, 0.835 and 0.931 respectively, which are all greater than 0.80, indicating that each potential variable has good internal consistency reliability. In addition, there are no observed variables with a correlation degree CITC (Corrected Item Total Correlation) value lower than 0.5 in the results, indicating that the setting of all observed variables meets the research needs.

4.1.2 Validity Analysis

Based on the previous literature review and professional cognition, the observed variables used to describe the latent variables in the questionnaire were defined in the form of pre-investigation, which ensured that the model had high validity. At the same time, based on Amos 24.0 software, exploratory factor analysis (EFA) was conducted on the validity of the questionnaire structure. The results show that the KMO (Kaiser Meyer Olkin) test value of the model sampling adequacy is 0.903, and the Bartlett's spherical test value is significant (SIG. < 0.001), indicating that the questionnaire has good structural validity.

4.2. Model fit test

In Amos 24.0 software, the maximum likelihood estimation method was used to estimate the parameters of the measurement model fitting index. The results show that the model chi-square/degree of freedom value is 1.437, which is between 1 and 3; The root mean square of approximate error (RMSEA) is 0.033, less than 0.05; The values of GFI, AGFI, NFI, TLI, IFI and CFI are all greater than 0.9, which are within the acceptable range, indicating that the fitting degree between the hypothetical model and the observed data is good, and the interpretation of the sample data is ideal.

4.3. Model results

The model path analysis results of perceived biodiversity affecting attention restoration show that each standardized path coefficient is significant at the level of 0.05, 0.01 or 0.001. A1 bird perceived biodiversity level, A2 insect perceived biodiversity level, A3 trees perceived biodiversity level and A4 flower perceived biodiversity level all have significant positive correlation with attention restoration (Table 6). That is, the experimental results support the above-mentioned research hypothesis and demonstrate the view that The higher the biodiversity of environmental perception, the more effective it is in promoting attention restoration.

Table 6. SEM normalized path coefficient results and their p values.

Model category	Path	*P* value	Normalized path coefficient
Structural model	B←A1	0.015	0.542
	B←A2	0.004	0.453
	B←A3	0.017	0.357
	B←A4	0.024	0.318
Measurement model	A1←A1a	0.000	0.834
	A1←A1b	0.001	0.745
	A1←A1c	0.007	0.872
	A2←A2a	0.013	0.845
	A2←A2b	0.001	0.816
	A2←A2c	0.026	0.739
	A3←A3a	0.000	0.867
	A3←A3b	0.009	0.826

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A3 ← A3c	0.000	0.881
A3 ← A3d	0.019	0.723
A4 ← A4a	0.006	0.795
A4 ← A4b	0.000	0.853
A4 ← A4c	0.000	0.876
A4 ← A4d	0.028	0.714
B ← B1	0.000	0.878
B ← B2	0.000	0.882
B ← B3	0.003	0.894
B ← B4	0.018	0.762

At the same time, relying on the above-mentioned relationship model: 1) taking gender, age, education level and average monthly income as control variables, group comparative analysis is carried out within each variable; 2) The total number of species of trees, shrubs and grasses in the park and the park area were used as control variables to analyse the difference in the actual biodiversity and spatial size among the parks. The results show that, in addition to educational level, five control variables, gender, age, average monthly income, actual biodiversity, and the size of the park area do not have a clear correlation moderating effect on the respondents' attention restoration (Table 7).

Table 7. Mean value of standardized path coefficient of structure model (B ← A) for each park

Park name	Number of species of trees, shrubs and grasses (approximate)	Park area (ha)	Mean value of normalized path coefficient of structure model (B ← A) for each park
Shaping Park	890	17.20	0.398
Eling Park	830	6.63	0.408
Nanshan Botanical Garden	250,0	551.00	0.443
Zhaomushan Forest Park	113,0	286.67	0.412
Caiyun Lake Wetland Park	680	107.07	0.426

5. Conclusion and discussion

(1) From the perspective of the four first-level observed variables describing attention restoration, coherence shows the greatest influence effect, and the other three variables are in descending order of fascination, being away and compatibility. For the four selected categories of perceived biodiversity, birds and flowers have a great effect on perceived biodiversity promoting attention restoration, while insects and trees have a big one. From the path coefficient results of the observed variables corresponding to the perceived biodiversity of different categories, it can be seen rare species diversity, species diversity, tactile diversity and olfactory diversity have the greatest influence on the perceived biodiversity of birds, insects, trees and flowers, respectively (Table 6).

(2) Under each biological category, educational level is the only demographic control variable that moderates perceived biodiversity experience, showing the association characteristic of "the higher the educational level, the more obvious the recovery effect is". The reason for this feature may be: Experiencers with higher education level tend to have higher cognitive consumption of work or study, are more prone to mental fatigue, and have a more urgent need for attention restoration. At the same time, in the longer education process, because there are more ecological learning opportunities and the follow-up relatively diverse ecological knowledge acquisition channels, they have a higher cognitive literacy of

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biodiversity. It is the bidirectional attributes of these two levels that determine that people with higher educational level can often obtain more restorative benefits in relevant experience.

(3) In fact, the impacts of biodiversity and park area on attention restoration do not show a correlation trend of "the higher the actual biodiversity or the larger the park area, the more obvious the restoration effect is" -- The attention restoration efficiency of parks with high actual biodiversity and large area may be weaker than that of parks with low actual biodiversity and small area (Table 7). This conclusion not only verifies the distinct inconsistency between measured biodiversity and perceived biodiversity from the perspective of the impact of biodiversity on attention restoration, but also shows that: from the perspective of maintaining ecosystem health and promoting people's mental health, it is an effective method to comprehensively improve the biodiversity quality of urban parks to deeply optimize the green space environment.

The above analysis results can provide useful reference for the follow-up theoretical exploration and design practice of perceived biodiversity promoting attention restoration. Based on the above research results, the author further derives the following thoughts.

(1) Perceived biodiversity can provide urban residents with cultural ecosystem services by promoting attention restoration, which is an effective scheme for healthy urban construction through the medium of nature. In terms of public health intervention, perceived biodiversity can be taken as an important component of urban mental health care infrastructure construction; In the aspect of landscape space experience and design, it can be used as an important reference index to evaluate the quality of environmental healing.

(2) The perceived degree of biodiversity is not only affected by the objective factors mentioned above, but also by subjective conditions such as the cognitive level and emotional difference of the perceiving subject for biology, ecosystem and even nature. Therefore, in terms of the effect of perceived biodiversity on attention restoration, under the same environmental conditions, the more species characteristics that the experience subject can recognize or understand, the higher the perceived biodiversity. The ability to draw "nutrition" from the biodiversity environment to restore attention is stronger as well.

(3) In the analysis of the relationship between measured biodiversity and perceived biodiversity and human well-being, the former is biased towards the objective ecological significance interpretation, while the latter pays attention to the subjective psychological impact evaluation. Two environments with the same area size and the same measured biodiversity abundance may have significant differences in perceived biodiversity quality. Therefore, how to increase residents' perception of biodiversity acquisition according to residents' aesthetic preferences and spatial characteristics, such as by increasing the number of attractive species, exposure time, and improving the contact opportunities and proximity index with attractive species, is the core focus of specific planning practice under the guidance of perceived biodiversity promoting mental health.

6. Epilogue

Compared with the development of ecological theory and practice of measured biological diversity and structural biological diversity, the landscape space construction guided by the perception of biological diversity and the promotion of attention restoration is a "flexible" sustainable planning and design method based on subjective psychological well-being, which plays a positive role in promoting and supplementing the continuous improvement of the current landscape ecology related concepts and design paradigms.

Based on the perspective of attention restoration, this paper conducts a preliminary study on the psychological health effects of perceived biodiversity, and demonstrates the causal relationship between them. However, the exploration of human-nature relationship based on the perception of biological diversity must be a very grand proposition, which needs to be studied in a wide range of subjects and involves many different disciplines. For example, from a more refined perspective, targeted studies on different social groups, a wider range of green space categories, perceived exposure duration effects, and the identification of highly perceived charismatic species groups are important research directions to explore by more cross-vision and evidence-based methods in the future.

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Corresponding Author: Xi CHEN, E-mail: cx_jiayou@163.com

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