

A Framework Study of the Effects of Neurourbanism Perspectives on the Impact of Neighbourhood Green Space Exposure on Adolescent Mental Health

Zhenyu Yao

Southwest University of Science and Technology, Mianyang, China
yaozhenyudgr@163.com

Abstract: *Neurourbanism, as an emerging interdisciplinary research method, builds a bridge between green space and adolescent mental health research. Based on Neurourbanism perspective, this paper combines the innovative methods of street maps, image processing and other measurement technologies to construct a conceptual framework of the effect of dynamic exposure to neighborhood green space on the mental health of adolescents and to improve the system of measuring exposure to green space in the neighbourhood. The study will consider the exposure to green space in adolescents' daily activities and their individual behaviours, and propose a mechanism model of "space-exposure-individual-neuroscience-health". This will make up for the lack of attention to the human scale in the existing green space exposure measurement, accurately quantify the individual's perception of green space exposure in daily activities, and assess the fairness of green space exposure in a more scientific way. This will provide a theoretical framework and empirical research basis for the construction of youth-friendly communities and urban green space planning.*

Keywords: *Neurourbanism, Neighbourhood Green Spaces, Dynamic Exposure, Adolescents, Mental Health, Impact Effects, Framework Construction*

1. Introduction

Mental health problems among adolescents (12-17 years old) continue to increase globally, with global epidemiological data showing that higher than 10-20% of adolescents suffer from mental illness^[1]. Studies have shown that fast-paced urban life and high-density development leading to decreasing green space are important factors in triggering various mental health problems^[2]. By 2050, about 70% of the global population will live in cities^[3], and exploring urban green space has an undeniable importance for adolescents' mental health.

Neighbourhood green space is an indispensable part of the urban habitat system, which has an important role in promoting the mental health of residents^[4]. Therefore, neighbourhood green space can not only enhance the positive emotions of adolescents and keep them away from daily troubles, but also potentially reduce their physical burden. The research suggests that this research direction can be realised through an interdisciplinary approach between neuroscience and urban planning, for which the concept of "Neurourbanism" was proposed^[5]. Neurourbanism can link public mental health and urban planning to create better environments, improve the mental health of individuals and communities in cities, and increase the resilience of at-risk individuals and children. Most of the current research focuses on the characteristics of green spaces' own attributes and their impact on the mental health of groups^[6], and these studies analyse mental health impact effects based on green spaces in static geographic contexts such as settlement buffers, postal code areas, and census areas^[7]. However, the locations where individuals are active or travelling are not limited to static geographic contexts, and their health is also affected by the environmental factors they are exposed to^[8]. Neurourbanism as an interdisciplinary research theory explores the link between environmental exposures and the physiological and psychological health of individuals as a cornerstone of the causal pathways between the environmental exposures to which they are exposed, their bodies, brains, psyches and behaviours.

Therefore, this study constructs a clear and basic conceptual framework of influence effects based on the Neurourbanism perspective, and the complexity of the causal relationship between dynamic exposure to community green space and adolescent mental health can be illustrated by exploring the mechanism model between the influencing factor variables, which can be used to guide the survey study and

subsequent research, and to provide a theoretical framework for the construction of adolescent-friendly neighbourhoods and urban green space planning. The framework model can be used to guide the research and subsequent studies, providing a theoretical framework and the basis for empirical research.

2. Domestic and overseas related research

Mental health is particularly important for adolescents because the rapid development of the adolescent brain makes them especially vulnerable to chronic emotional illnesses and mental health problems^[9]. Neuroscience-based studies of urban environments on children's mental health have focused on the built and natural environments, with urban green spaces being the focus of research. Neurourbanism research suggests that individual characteristics of adolescents, and environmental exposures can all influence the developmental outcomes of children's mental health by shaping cognitive neural processes, and Djohari et al. concluded that blue and green spaces in the city can help children better manage their emotions^[10], reduce children's stress and depressive symptoms, as well as promote opportunities for social interaction^[11]. The above studies suggest that both long-term and short-term exposure to urban green spaces can have some degree of benefit for children's mental health. Neighbourhoods, being the environments where children spend relatively the longest time and have the most intensive activities, neighborhood green space and children's mental health are interdependent in many ways^[12]. van Lier et al. concluded that neighbourhood parks and small gardens were associated with lower levels of improvement in depressive symptoms and enhanced emotional well-being^[13]. dzhambov et al. demonstrated through their study that neighborhood green space coverage density improves children's mental health and improve children's overall quality of life^[14].

Research on urban green space in China has mainly focused on three aspects: ecosystem service evaluation, planning and development, and tourism and recreational use. In contrast, foreign scholars have explored the great significance of urban green space for human well-being, including its effects on increasing physical activity, promoting social interaction, and enhancing physical and mental health and well-being^[15]. A growing number of horizontal and longitudinal interdisciplinary studies have concluded that green spaces are associated with mental health-related benefits such as cognitive functioning, attention restoration, stress reduction and positive emotions^[16]. And the potential pathways and mechanisms between green spaces and mental health have been explored in depth. For example, Hartig et al. suggest that green spaces are linked to health through four pathways: air quality, physical activity, social co-operation and stress reduction^[8], and Markevych et al. identify three main pathways: harm reduction, resilience, and building capacity^[17]. Similarly, a recent systematic review by Ru Zhang et al. summarised the mechanisms of influence between green spaces and mental health, including mitigating harmful exposures, psychological recovery and encouraging health-related behaviours^[18]. Attention Recovery Theory (ART) and Stress Recovery Theory (SRT) are thus seen to provide a basis for the study of benefits in green spaces. In addition to this, environmental epidemiology in Neurourbanism research suggests that the scope of urban green space research has expanded from environmental aesthetics to environmental medicine, from physiological health to mental health, and from rehabilitative landscapes to healthy cities^[19]. The Neurourbanism perspective of "environment-population-neuroscience-health" has become the focus of research and attention to explore the impact of exposure to urban green space on population health^[20]. For example, one study combines Neurourbanism with urban planning and public health to propose a new research framework for understanding the relationship between urban environments and young people's mental health, emphasising the potential for cross-disciplinary interactions and collaborations^[21], which examines the cognitive load that urban environments place on the brain and how it is perceived by young people and affects their mental health.

Neurourbanism is supported by neuroscience theory, which places the brain in a dynamic environment and focuses on the dynamic environment in which the human body is situated. Neurourbanism theory explains the mechanism of interaction between the individual and the environment, mediated by the human body and the neural activity (brain), which is the substantial and intrinsic cause of the effects, thus proposing the interaction mechanism of "environment-individual-brain-mental health". Previous studies have found that exposure to urban green space is beneficial to the physical and mental health of populations, but green space exposure studies usually use static administrative areas as contextual areas to assess green space, which leads to biased estimates because it ignores daily dynamic exposure characteristics^[22]. Therefore, some recent studies have investigated the impact of dynamic green space exposure on mental health under individual differences and social influences using the Uncertain Geographic Contextual Issues (UGCoP) perspective^[23], e.g., Ruoyu Wang et al. ^[24] showed that all dynamic green space exposure in residential areas was associated by examining the relationship between dynamic green space exposure and residents' mental health. Another example

is Suhong Zhou et al^[25] confirmed that the dynamic nature of slightly individual daily behaviour may lead to unreliable results, and the study found that there is a large difference in the level of individual environmental exposures based on static and dynamic buffer zones. These findings enrich our understanding of dynamic environmental influences on mental health and provide valuable insights for urban planning and public health services.

Therefore, on the basis of previous studies, this study proposes a more comprehensive and fundamental conceptual framework for the study of the impact of dynamic exposure to neighbourhood green space on adolescent mental health, to help people more deeply and accurately understand the effects of dynamic exposure to neighbourhood green space on adolescent mental health, and to establish a close connection between the physical space of urban and rural planning, gardening and other disciplines and the mental health elements of environmental epidemiology through the lens of Neurourbanism. mental health elements through the perspective of neurourbanism.

3. Framework and Mechanism Modelling of Impact Effects of Exposure to Neighbourhood Green Space

3.1. A framework for the effects of dynamic exposure to neighbourhood green space on adolescent mental health

Based on the theory of Neurourbanism and the characteristics of neighborhood green space and individual activities of adolescents, a conceptual framework for the study of the impact of dynamic exposure to neighbourhood green space on adolescents' mental health was constructed from the perspective of the interaction of "environment-individual-brain-mental health" (Figure 1). The key to the study is to identify the pathways of neighborhood green space exposure on mental health, which involves a complex cascade of ecological and geographic processes that link the dynamic exposure of neighborhood green space to the impacts on adolescents' mental health. Of importance is the consideration of the extent of adolescents' dynamic exposure to neighbourhood green space (including how to capture adolescents' dynamic spatial exposure and assess the characteristics of dynamic exposure to neighbourhood green space) and the moderating effects of individual differences and social influences, as well as Neurourbanism-based measures.

3.1.1. Dynamic exposure of adolescents in neighbourhood green space

For the extent of adolescents' dynamic exposure in neighbourhood green space, the first consideration is to capture adolescents' dynamic spatial exposure; previous studies have commonly used census neighbourhoods, residential areas, and circular buffer zones around residences to capture spatial exposure, and these methods are subject to the Uncertain Geographic Contextual Problem (UGCoP). This mismatch is particularly pronounced for adolescents, where traditional methods relying on static boundaries or buffer zones are unable to capture the dynamic spatial exposure of adolescents; at the same time, the adolescent population is in the stage of regular education and learning, where behavioural activities in the daily external space are limited in time and space, such that the adolescents' daily behavioural activities basically take place in the external space of their schools and settlements. Therefore, Oliver et al^[26] introduced a linear spatial exposure buffer based on a road network, which is a more sensitive measure than the traditional method, thus making it easier to capture the dynamic spatial exposure of adolescents. This dynamic linear buffer distance was chosen based on the urban characteristics of the study area and the spatial scale/extent of adolescents' daily physical activity (Monday to Friday) and travelling^[27]. Buffer zones based on the location of this activity and travelling routes have been shown to be effective in capturing environmental exposures.

On the basis of the above, the ability of green space to be adequately "exposed" is a basic prerequisite and a necessary way for it to achieve various types of health benefits. "Exposure" refers to the degree of exposure to green space based on certain green space characteristics (e.g., quantity, distance, quality, etc.)^[28]. Therefore, this study proposes a multidimensional systematic neighborhood green space dynamic exposure level measurement system (Figure 2) based on environmental epidemiology and uncertain geographic context problem (UGCoP) by dividing the neighborhood green space dynamic exposure level into neighborhood green space dynamic potential exposure level and dynamic actual exposure level^[29]. The dynamic potential exposure level of green space includes availability, accessibility. Green space dynamic actual exposure includes visibility and perceivability.

3.1.2. Individual differences and social influences

For the moderating effects of individual differences and social influences, mental health in adolescence is strongly influenced by personal experiences as well as the social environment^[30]. In terms of individual differences, the mental health benefits from green space exposure can vary among individuals. Therefore, personal and social attribute characteristics (including gender, age, family income, etc.) have been studied as control variables in the effects of green space exposure on mental health. Previous studies have shown that the effects of green space exposure on mental health are achieved through the indirect and direct effects of moderating variables, proposing that individual behaviours, physical activity, and use of activities are an important part of the mechanism explaining the effects on mental health^[31]. At the level of social influence, socio-economic factors, physical environment (including traffic noise) and social environment factors (including social cohesion and sense of security, etc.) all have an impact on the mental health of residents^[32]. Environmental behavioural surveys such as activity logs, behavioural notations, photo projection and cognitive maps, combined with conventional questionnaires and semi-structured interviews, can be used to obtain information on the frequency and duration of exposure to green space, walking routes and activities, as well as individual community participation, neighbourhood attachment and physical activity^[33].

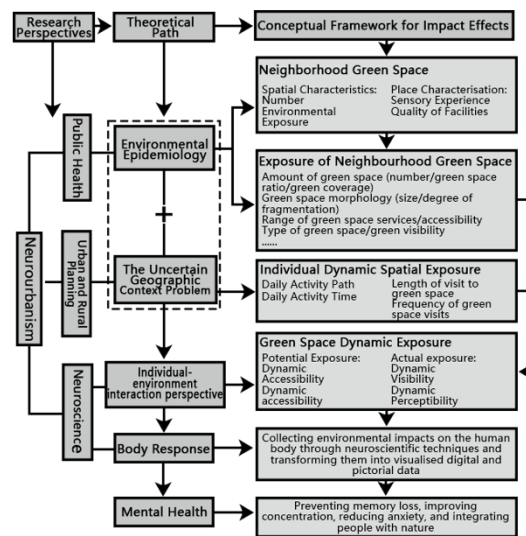


Figure 1: A framework for the effects of dynamic exposure to neighbourhood green space on adolescent mental health.

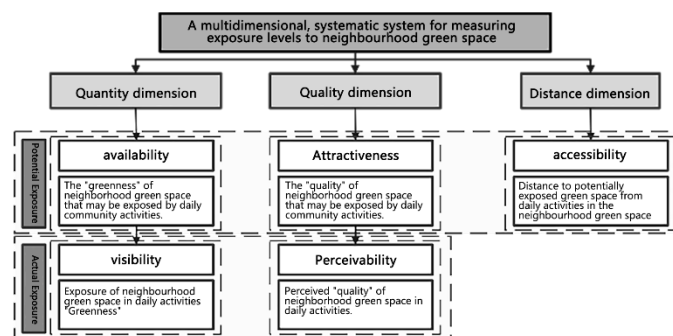


Figure 2: Dynamic exposure level measurement system for neighborhood green space.

3.1.3. Neuroscience-based measures of mental health

Interdisciplinary research between life sciences has become the latest contribution of neuroscience, especially the emerging fields of neurourbanisation and neuroarchitecture when applying neuroscience technology to the study of cities, buildings and landscapes, so that all of these disciplines can flourish^[34]. Neuroscience and technology have also injected new scientific basis and research methods into the research of urban and rural planning and landscape architecture. In the current research, the subtle effects of the environment on the human body are mainly collected by means of neuroscience techniques, such as eye movement, brain cognition, and biosensing, which are transformed into physiological data such

as visualised figures and images (Table 1).

Table 1: Neurourbanism technological instruments.

| | Measurement method | Measurement indicators | Technical principles |
|----------------------------|-------------------------------------------------|------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Eye-tracking Technology | Eye Movement Meter | Eye movements | Record eye movement position, gaze duration, trajectory and other metrics to understand the subject's feedback on real-time information and to speculate on their thoughts and intentions |
| Brain Cognition Technology | Electroencephalogram (EEG) | Brain potential | Graphs obtained from the scalp by amplifying and recording the spontaneous bioelectrical potentials of the brain, which correspond to different sensations in the human body |
| | Event-related Potential (ERP) | Brain potential | EEGs obtained from a series of tests are aligned based on external events (e.g., stimulus presentation or response) and averaged on top of each other |
| | Magnetoencephalography (MEG) | Electromagnetic field of the brain | Direct measurement of extremely weak biomagnetic field signals from neural currents in the brain |
| | Functional Magnetic Resonance Imaging (fMRI) | Local blood flow to the brain | Functional brain imaging by examining changes in the magnetic field of blood flow into brain cells to obtain neural activity in various regions of the brain |
| | Functional Near Infrared Spectroscopy (fNIRS) | Local blood flow to the brain | Measurement of changes in oxyhaemoglobin and deoxyhaemoglobin concentrations in brain tissue following neuronal activation |
| | Positron Emission Tomography (PET) | Isotopic tracers | After labelling and injecting a substance necessary for the life metabolism of living organisms into the human body, the molecular changes of the metabolite are measured in vitro to reflect the life metabolic activities. |
| Biosensing Technology | Temperature, ECG, ECG, Respiratory Sensor, etc. | Skin temperature, skin perspiration, cardiovascular activity, respiratory activity, etc. | Regulated by the nervous system, including the hypothalamus, sympathetic and parasympathetic nerves, emotional experiences are characterised by a range of physiological responses that can be accurately and rapidly measured by biosensors. |

4. Modelling of impact mechanisms

On this basis, the study proposes a "space-exposure-individual-response-health" model based on the Neurourbanism theoretical framework (Figure 3). The dynamic exposure to green space affects mental health either directly or indirectly through neural response, in which the direct effect refers to the individual's psychological recovery from stress and attention fatigue through the individual's interaction with the environment and direct contact with green space exposure. Indirectly, green spaces influence mental health by altering the physical environment and providing a place for the public to engage in activities and interactions, and by enhancing social cohesion through individual behavioural exposures,

thereby promoting healthy behaviours and positive emotions. Research on impact mechanisms can help to identify dynamic exposures to green space that are effective in producing mental health benefits.

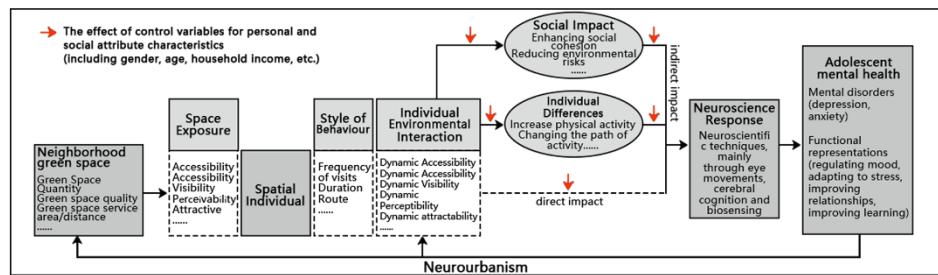


Figure 3: Mechanisms modeling the impact of dynamic exposure to neighborhood green spaces on adolescents' mental health.

5. Implications and Prospects

This paper constructs a conceptual framework of neighborhood green space dynamic exposure affecting adolescent mental health based on Neurourbanism perspective, and explores the different impact effects of neighborhood green space dynamic exposure affecting adolescent mental health indicators. The level of dynamic exposure to community green space is measured in terms of availability, accessibility, visibility, perceivability attractiveness of green space exposure, and an innovative approach combining street maps, image processing, and measurement techniques is used to measure the level of exposure. Based on the problem of uncertain geographical background, the study focuses on the interaction between individuals and their environments, takes into account the exposure to green space of adolescents in neighbourhood activities, and proposes a framework of "environment-individual-brain-mental health", which is conducive to the identification of factors affecting mental health. In this way, it makes up for the lack of attention to the human-scale green space environmental characteristics reflected in the existing green space exposure measurement methods, avoids the bias of green space exposure measurement caused by ignoring the daily activities of individuals, and realises the accurate quantification of the green space exposure perception from static to dynamic daily activities of individuals, so as to evaluate the fairness of green space exposure in a more scientific way. The framework and mechanism of the effect of dynamic exposure to neighborhood green space on adolescent mental health are of guiding significance for the construction of neighborhood green space and the intervention of adolescent mental health.

References

- [1] World Health Organization.. Adolescent mental health. <https://www.who.int/news-room/fact-sheets/detail/adolescent-mental-health>. 2021.
- [2] Pykett J, Osborne T, Resch B. From Urban Stress to Neurourbanism: How Should We Research City Well-Being?[J]. *Annals of the American Association of Geographers*, 2020, 110(6):1936-1951.
- [3] UN News. World Cities Day: Value Communities, Today and for the Future[EB/OL]. (2020-10-29)[2021-03-02]. <https://news.un.org/en/story/2020/10/1076402>.
- [4] Dong H, Qin B. Exploring the link between neighbourhood environment and mental wellbeing: A case study in Beijing, China[J]. *Landscape and Urban Planning*, 2017, 164:71-80.
- [5] Adli M, Berger M, Brakemeier E, et al. Neurourbanism: towards a new discipline[J]. *The Lancet Psychiatry*, 2017, 4(3):183-185.
- [6] Kwan M, Wang J, Tyburski M, et al. Uncertainties in the geographic context of health behaviors: a study of substance users' exposure to psychosocial stress using GPS data[J]. *International Journal of Geographical Information Science*, 2019, 33(6):20.
- [7] ZHANG L, ZHOU S, KWAN M, et al. Impacts of Individual Daily Greenspace Exposure on Health Based on Individual Activity Space and Structural Equation Modeling[J]. *International Journal of Environmental Research and Public Health*, 2018,15(10): 2323.
- [8] Hartig T, Mitchell R, de Vries S, et al. Nature and Health[J]. *Annual Review of Public Health*, 2014, 35(1):207-228.
- [9] Dahl R E. Adolescent Brain Development: A Period of Vulnerabilities and Opportunities. Keynote Address [J]. *Annals of the New York Academy of Sciences*, 2004, 1021(1):1-22.
- [10] Djohari N, Brown A, Stolk P. The comfort of the river: understanding the affective geographies of

- angling waterscapes in young people's coping practices [J]. *Children's Geographies*, 2018, 16(4):356-367.
- [11] Feda D M, Seelbinder A, Baek S, et al. Neighbourhood parks and reduction in stress among adolescents: Results from Buffalo, New York [J]. *Indoor and Built Environment*, 2015, 24(5):9.
- [12] Chen Tian, Wang Jiayu, Shi Chuanmiao. Research on child-friendly orientated public space design strategy for eco-communities--Taking Sino-Singapore Tianjin Eco-city as an Example[J]. *Shanghai Urban Planning*, 2020(03):20-28.
- [13] van Lier L E, Utter J, Denny S, et al. Home Gardening and the Health and Well-Being of Adolescents [J]. *Health Promotion Practice*, 2016, 18(1):34-43.
- [14] Dzhambov A, Hartig T, Markevych I, et al. Urban residential greenspace and mental health in youth: Different approaches to testing multiple pathways yield different conclusions[J]. *Environmental Research*, 2018, 160:47-59.
- [15] Zhang Shuying, Liu Jiaming, Zhu He, et al. Research progress of urban ecological open space at home and abroad[J]. *Human Geography*, 2019, 34(05):15-25.
- [16] Campagnaro T, Vecchiato D, Arnberger A, et al. General, stress relief and perceived safety preferences for green spaces in the historic city of Padua (Italy) [J]. *Urban Forestry & Urban Greening*, 2020, 52: 10.
- [17] Markevych I, Schoierer J, Hartig T, et al. Exploring pathways linking greenspace to health: Theoretical and methodological guidance [J]. *Environmental Research*, 2017, 158:17.
- [18] Zhang R, Zhang C, Rhodes R E. The pathways linking objectively-measured greenspace exposure and mental health: A systematic review of observational studies [J]. *Environmental Research*, 2021, 198:10.
- [19] Hou Yun-Jing, Zhao Xiao-Long, Zhu Xun. Evolution of Western Landscape Architecture Based on Health-trend[J]. *Chinese Landscape Architecture*, 2015, 31(4):101-105.
- [20] L. I. Chang. Research on the Health Effects of Urban Green Space from the Perspective of Environmental Epidemiology [J]. *Landscape Architecture*, 2021, 28(8):94-99.
- [21] Buttazzoni A, Doherty S, Minaker L. How Do Urban Environments Affect Young People's Mental Health? A Novel Conceptual Framework to Bridge Public Health, Planning, and Neurourbanism [J]. *Public Health Reports*, 2021, 137(1):48-61.
- [22] Wang B, Xu T, Gao H, et al. Can daily mobility alleviate green inequality from living and working environments? [J]. *Landscape and Urban Planning*, 2021, 214:12.
- [23] Kwan M. The Uncertain Geographic Context Problem [J]. *Annals of the Association of American Geographers*, 2012, 102(5):958-968.
- [24] Wang R, Feng Z, Pearce J, et al. Dynamic green space exposure and residents' mental health in Guangzhou, China: From over-head to eye-level perspective, from quantity to quality[J]. *Landscape and Urban Planning*, 2021, 215:10.
- [25] Zhang L, Zhou S, Kwan M, et al. Assessing individual environmental exposure derived from the spatiotemporal behavior context and its impacts on mental health [J]. *Health & Place*, 2021, 71:10.
- [26] Oliver L N, Schuurman N, Hall A W. Comparing circular and network buffers to examine the influence of land use on walking for leisure and errands[J]. *International Journal of Health Geographics*, 2007, 6(1):41.
- [27] Maddison R, Jiang Y, Hoorn S V, et al. Describing Patterns of Physical Activity in Adolescents Using Global Positioning Systems and Accelerometry[J]. *Pediatric Exercise Science*, 2010, 22(3):392-407.
- [28] Bratman G N, Anderson C B, Berman M G, et al. Nature and mental health: An ecosystem service perspective [J]. *Science Advances*, 2019, 5(7):14.
- [29] Jinguang Z, Zhaowu Y, Bing Z. Impact Mechanism of Urban Green Spaces In Promoting Public Health: Theoretical Framework And Inspiration For Practical Experiences. [J]. *Landscape Architecture Frontiers*, 2020, 8(4):104-114.
- [30] Allen J, Balfour R, Bell R, et al. Social determinants of mental health[J]. *International Review of Psychiatry*, 2014, 26(4):392-407.
- [31] Tan Shaohua, Yang Chun, Li Lifeng, et al. Progress of research on health restoration impacts of park environment [J]. *Chinese Garden*, 2020, 36(02):53-58.
- [32] Generaal E, Timmermans E J, Dekkers J E C, et al. Not urbanization level but socioeconomic, physical and social neighbourhood characteristics are associated with presence and severity of depressive and anxiety disorders[J]. *Psychological Medicine*, 2019, 49(1):149-161.
- [33] Zhao Xiaolong, Qiu Xuan, Xu Jingran, et al. A review of research methods on usage behaviour and environmental cognition in green space[J]. *Landscape Architecture*, 2020, 27(03):56-62.
- [34] Pykett J, Osborne T, Resch B. From Urban Stress to Neurourbanism: How Should We Research City Well-Being? [J]. *Annals of the American Association of Geographers*, 2020, 110(6):1936-1951.