land

MDPI

Article

Evaluation of Emotional Attachment Characteristics of Small-Scale Urban Vitality Space Based on Technique for Order Preference by Similarity to Ideal Solution, Integrating Entropy Weight Method and Grey Relation Analysis

Ruoshi Zhang

School of Landscape Architecture, Beijing Forestry University, Beijing 100083, China; zhang_rs@bjfu.edu.cn; Tel.: +86-181-0120-2557

Abstract: The research and design of urban vitality spaces is recognized as an important part of current urban construction and development, especially for China's first-tier cities at the background of stock renewal. Aiming to address the lack of quantitative methods for research and evaluation of the emotional attachment between people and the built environment in small-scale urban vitality spaces, a new method that can quantify emotional attachment data into comprehensive vitality evaluation results is proposed here. Five representative vibrant urban renewal complexes in China were chosen to demonstrate the feasibility of the method. The method includes three steps. First, an evaluation index system of emotional attachment in small-scale urban vitality spaces was created, including 14 indicators from three aspects: attachment degree, attachment dimension, and attachment intensity to specific built environment characteristics. Second, the indicators obtained were preliminarily processed and the correlation analysis was carried out using SPSS to provide support and interpretation for subsequent evaluation. Third, the results of multiple indicators were organized through the improved technique for order preference by similarity to ideal solution (TOPSIS), integrating the entropy weight method (EW) and the grey relation analysis method (GRA) to produce an attachment evaluation result for the five complexes. This study demonstrates that small-scale built environment characteristics can effectively promote urban vitality by as people establish multidimensional emotional attachment with them. Physical material characteristics can deepen people's emotional attachment and promote spatial vitality by retaining and renovating historical material and structure or intervening in emerging forms that reflect current trends. Social and interactive characteristics are closely correlated with material characteristics, but their influence on urban vitality changes dynamically with time and the surrounding environment. Additionally, the construction and application of the methodology is scrutinized in order to provide new ideas for the design, research, and evaluation of small-scale urban vitality spaces.

Keywords: emotional attachment characteristics; urban vitality evaluation; small-scale vibrant spaces; emotional attachment scale; EW–GRA-TOPSIS method

check for updates

Citation: Zhang, R. Evaluation of Emotional Attachment Characteristics of Small-Scale Urban Vitality Space Based on Technique for Order Preference by Similarity to Ideal Solution, Integrating Entropy Weight Method and Grey Relation Analysis. *Land* **2023**, *12*, 613. https://doi.org/10.3390/land12030613

Academic Editor: Thomas Panagopoulos

Received: 16 February 2023
Revised: 1 March 2023
Accepted: 2 March 2023
Published: 4 March 2023

Copyright: © 2023 by the author. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (https://creativecommons.org/licenses/by/4.0/).

1. Introduction

1.1. Research Background

The speed and breadth of Chinese urbanization are considered the two major factors affecting the development of human society in the 21st century, on a par with the high-tech development of the United States [1]. In recent years, Chinese urbanization has entered the stage of stock renewal, and in order to respond the overall policy of connotative growth for achieving a higher quality of human life [2], creating urban vitality space is of vital importance to urban renewal research and practice [3,4]. Renovating the existing built environment through the construction of diversified urban complexes has become one effective way of creating these spaces [5–7]. At present, whether in first-tier cities

such as Beijing, Shanghai, and Guangzhou, or in new first-tier cities such as Chengdu and Nanjing, we can see cases of the successful transformation of old buildings or urban blocks into representative urban vitality complexes, such as Xidan Renewal Field and Beijing Fun in Beijing, Xintiandi in Shanghai, Beijing Road in Guangzhou, Taikoo Li in Chengdu, etc. Additionally, the guiding strategy of "reducing quantity and improving quality" in urban renewal in Beijing's 2021–2025 Territorial Spatial Planning Policy shows that small-scale, gradual, and decentralized space is an indispensable part of urban vitality research and design, and further research and development in this area is necessary. At the same time, in the digital age, people's requirements for the urban built environment have long developed from basic functional satisfaction to advanced emotional attachment [8,9], and the realization of urban vitality also depends on the consideration of the emotional interaction between people and the built environment [10,11], as emotion is the driving force of "vitality".

Therefore, it is necessary to establish a research and evaluation method for small-scale urban vitality spaces represented by urban renewal complexes. In order to achieve this goal, emotional attachment theories provide a theoretical fulcrum for studying the characteristics of emotional attachment between people and the built environment and constructing measurement indicators, while the multi-criteria decision-making (MCDM) methodology represented by TOPSIS provides a tool for scientifically evaluating the level of the emotional attachment. Based on this, the emotional vitality evaluation method of urban renewal complex can be constructed. In this study, five representative urban renewal complexes in China's first-tier and new first-tier cities were selected as examples to verify the effectiveness of the above emotional attachment evaluation method of urban vitality, including Xidan Renewal Field and Qianmen Beijing Fun in Beijing, Xintiandi in Shanghai, Beijing Road in Guangzhou, and Taikoo Li in Chengdu. Firstly, based on emotional attachment theories, the emotional attachment scale for the spatial characteristics of specific built environments were constructed and used to measure the degree and dimension of attachment, as well as the intensity of the spatial characteristics of the specific built environment of the five complexes. Then, SPSS software was used to process the scale data so as to construct an attachment evaluation index, and the improved TOPSIS (technique for order preference by similarity to an ideal solution) method, combined with EW (entropy weight) and GRA (grey relation analysis), was used to rank the level of urban vitality concerning emotional attachment for the five complexes. Last but not least, the evaluation results were coupled with the correlation analysis results of the scale data to further explore the commonalities and differences of the spatial characteristics that promote emotional attachment in the five complexes.

1.2. Literature Review

1.2.1. Study on Urban Vitality from the Perspective of Emotional Attachment

To understand urban vitality from the perspective of emotional attachment, it is necessary to explore the definition and connotation of its keyword "vitality". As a theorist and activist in the field of urban studies, Jane Jacobs, a proponent of "urban vitality", defined it as the ability of space to attract and carry people's various activities [12]. She particularly maintained that vibrant urban space always consists of the physical environment promoting people's positive emotions. Gehl and Lynch emphasized the interaction between people and vibrant urban spaces, as well as various activities that are motivated by the process [13,14]. Maas described urban vitality as a representation of spatial quality consisting of the continuous presence of people, activities, and the physical environment in which these activities take place [15]. Montgomery deepened the connotation of vitality by considering people's emotional experience, and defined urban vitality as "the extent to which a place feels alive or lively" [16]. After more than half a century of improvement by multidisciplinary scholars, regardless of perspective or space scale, urban vitality is always associated with the built environment, involving a high density of users [12,17,18], diverse activities [19–22], and mixed land use and space functions [14,23,24]. This also

makes the aforementioned urban complex an appropriate object for the study of urban vitality. Although there is no consensus on the definition of "urban vitality" due to the wide variety of disciplines involved [6], its core word "vitality" determines that the value of related research should be based on the creation of a living, built environment, as well as care for people's real feelings. In the digital age, the achievement of this vitality further demands care of people's advanced emotional needs [25,26]. In short, the construction and development of urban vitality space comes from the multidimensional interaction between people and the built environment, in which satisfying people's emotional demands for space is the core connotation of "vitality".

In general, current research on urban vitality is mainly focused on impact indicators and corresponding measurement frameworks. With the development of digital technology, especially the maturity of data mining and analysis technology, multidisciplinary scholars who have been active in the field of urban vitality researches in recent years have been deeply engaged in identifying the influencing factors of urban vitality through big data, including mobile phone data, social media data, Baidu heat map (BHM) data, and GPS tracking data [1,11,21,27–32]. These studies focus more on non-material categories of urban vitality, such as the relationship between urban vitality with the economy, society, history, and culture. Additionally, in the studies related to the built environment field, such as architecture, urban planning, geography, etc., researchers are keen to use various data collection and analysis techniques to simplify the complex behavioral activities of people in three-dimensional spaces and present them as two-dimensional heat maps or one-dimensional data indicators [32–34]. The discussion of the spatial characteristics of the built environment extends to the street scale at most [1,35,36], and rarely focuses on the small-scale, three-dimensional architectural characteristics that really promote the interaction between people and the built environment. The conclusions are either qualitative descriptions of the built environment or presented as abstract data indicators, which is difficult to truly reveal the specific physical characteristics of the vibrant space that can carry and trigger the user's behavior and emotions. It can be seen that attention to people's real interactive experience and emotional needs in urban spaces in the connotation of "vitality" is often weakened or even ignored in existing researches. On the one hand, relevant research needs to be carried out in a three-dimensional space close to the human scale and people's everyday lives, which is difficult to present in large-scale two-dimensional maps as regional geography or urban planning studies. On the other hand, the construction of the framework and indicators for objectively studying and evaluating emotional attachment to different built environment characteristics of the vibrant space also need to be supported by interdisciplinary theories and methods.

In summary, the research objects of urban vitality need deepening and expanding to the characteristics of the small-scale built environment, while it is also necessary to place more emphasis on people's emotional attachment to certain spaces, as emphasized by the connotation of "vitality".

1.2.2. Study on the Definition and Evaluation of Emotional Attachment between People and the Built Environment

The study regarding the emotional attachment between people and the built environment discusses the relationship between the two based on emotion, cognition, and behavior; herein, emotion ranks first [37,38]. They are conducted by multi-disciplinary scholars, including those involved in psychology, human geography, architecture, and urban planning [39]. Among them, the theoretical framework represented by place attachment theory systematically discusses the multi-dimensional influence factors, as well as indicators of the emotional attachment between people and specific built environment characteristics [37,38,40–42]. In the field of research related to the built environment, including architecture and urban planning, human-centered behavioral research pays attention to emotional attachment [43–46], as does place-based phenomenological research [47], and the exploration of the meaning of people-built environment interactions [48,49]. In psychology

and human geography, researchers systematically explore the establishment principle and internal mechanism of emotional attachment and construct multi-dimensional emotional attachment measurement scales, of which different indicators promoting emotional attachment are emphasized [9,38,42]. The convergence of multidisciplinary perspectives complements the emotional perspective lacking in current urban vitality researches, providing a way to quantitatively measure the emotional attachment between people and characteristics of the small-scale built environment.

In recent years, designers and researchers with multidisciplinary backgrounds have constructed a series of emotional attachment scales to measure the attachment between people and specific built environments, and have applied them in studies of various buildings and urban public spaces at home and abroad [8,26,41,44,50]. They include both physical characteristics of the built environment, such as material, form, structure, color, etc., and socio-cultural characteristics, such as sociability, territoriality, uniqueness, etc. In the digital age, research has expanded to explore the interactivity and variability of the built environment [50,51]. The results prove the reliability and validity of the scales, which, to a certain extent, supplement the problem of insufficient methods for quantifying the emotional attachment in built environment studies, and also provides reference and support for this study.

1.2.3. Study on the Evaluation of Urban Space Using TOPSIS Related Methods

As mentioned above, identifying influencing factors and constructing a measurement framework with the help of information and communication technology turns out to be one of the main focuses of urban vitality research. In order to further evaluate the effectiveness and compare the vitality characteristics of different spaces to make better decisions in the field of built environment design and construction, methods from MCDM/MCDA (multi-criteria decision-making/multi-criteria decision analysis) groups have been used as important supporting tools [52–54]. MCDM methods can be divided into aggregation methods and surpassing methods, with remaining methods devloped later [55]. They are believed to be capable of making the evaluation process of urban space more multidisciplinary, transparent, and participatory [56–60]. Among them, the AHP method and its modification FAHP are the most widely used in the field of built environment evaluation and decision-making processes such as POE (post occupancy evaluation) studies [61–65]. However, the TOPSIS method and its modified version were chosen instead for this study because of AHP's higher computational complexity and larger data requirements [55], as well as the interactions of different components and subsystems in one urban space can, which reduce the accuracy of AHP in the evaluation of the characteristic of attachment level between different spaces [66]. The TOPSIS (technique for order of preference by similarity to ideal solution) method was developed in 1981 by Hwang and Yoon to create both positive and negative ideal solutions, and then compare the degree of differentiation between the alternative and ideal solution (both positive and negative) [67]. As it is easier to operate and understand—and can make full use of the information from the original data, as well as reveal the detailed strengths and weaknesses of each specific characteristic more accurately—it is applied in many aspects of the evaluation of urban space, and is especially successful in evaluating various complex urban systems formed by people, the built environment, and the interaction between the two.

For example, the TOPSIS method is widely used in urban sustainability and urban resilience, as well as urban vitality studies, to establish an evaluation system that includes multiple indicators for social, economic, public transport, and ecological development [56,68–73]. EW (entropy weighting) and GRA (grey relation analysis) are always combined as part of this method, in order to assign weights for indicators and improve the accuracy of the evaluation process [69]. The study of urban vitality further focuses on the indicators related to people's activities and their coupling with geographic big data [74–76]. With the development of information technology and big data, the improved TOPSIS method has become further aligned with the GIS model and machine learning to

evaluate more complicated objects and visualize the results. This can be seen in studies on multidimensional urban environmental carrying capacity [70] and urban flood vulnerability [72]. Based on these, a series of comprehensive urban evaluation index systems were built with the help of a neural network technique [77]. In addition to the holistic evaluation of the urban system mentioned above, the improved TOPSIS method is also used to evaluate specific building, region, and design methodologies, such as the evaluation of the light environment of vernacular architecture and the effectiveness of the architectural morphology generation method [78–80]. Some studies have also tried to quantitatively measure people's awareness and cognition in their interactions with urban spaces with the help of the TOPSIS method [81]. However, few studies have applied the TOPSIS method to evaluate the impact of specific built environment characteristics on the users' emotional experience in urban vitality research, which is one of the indispensable parts of "vitality", as well as the core scope of this study.

1.3. The Main Goal of the Paper

Under the background of stock renewal, with "reducing quantity and improving quality" becoming the core demand of the planning and development of Chinese urban space, the design and research of vitality space needs to respond to the real needs of people in the moment to truly improve the quality of urban space. In the digital age, where people's emotional demands for urban space are increasing, it is necessary to consider the emotional attachment between people and the built environment in the creation of vitality, which, at the same time, is also the key to vitality itself. Based on this, the main goal of this study is composed of three interrelated parts: first, at the theoretical level, to supplement the discussion of the emotional attachment between people and small-scale built environment characteristics in the study of urban vitality, while improving the human-oriented connotation of vitality. Second, at the methodological level, based on emotional attachment scales and the EW-GRA-TOPSIS evaluation method, indicators and index system for measuring and evaluating the degree of emotional attachment between people and the built environment characteristic of urban vitality is constructed and applied, which, on the one hand, updates the methodology of urban vitality research, and, on the other hand, also provides a more scientific and objective quantitative approach for the evaluation of emotional attachment between people and the built environment. Third, at the practical level, taking five representative urban renewal vitality complexes in China's first-tier and new first-tier cities as examples, the validity of the indicators and index mentioned above is proven, which may hopefully provide an emotion-oriented reference for the design and evaluation of urban vitality space in the future.

Guided by these goals, there are three innovative points of this study. First, in terms of methodology, the TOPSIS method is improved through its combination with both the entropy weight to assign weights and grey relation analysis to reduce the subjectivity and uncertainty of the evaluation process, which can be used in further studies on the evaluation of urban vitality. Second, in terms of practice, the emotional attachment scale is modified to be more easily applied to built environment research, as its characteristics are constructed as the main indicators in the process of establishing emotional attachment. Additionally, the improved TOPSIS method can better cope with the complex evaluation of problems concerning the interaction between people and the built environment. The scale measurement and evaluation results are useful for architects, planners, and other urban development practitioners, which is conducive to the design and development of both new and existing buildings as emotion-oriented urban vitality spaces, and this study simplifies the process of selecting design elements and design methods that are emotionally connected. Third, in terms of empirical study, the theory of emotional attachment is introduced in the case study of five representative urban renewal complexes in China's first tier and new first tier cities to improve emotion-oriented evaluation and design methods, and the findings can inspire further studies on urban vitality in future process of Chinese urban renewal development. This study found that small-scale, built environment characteristics

can effectively promote people's emotional attachment to urban vitality spaces, of which the construction of diverse urban complexes is an effective method.

2. Materials and Methods

2.1. Study Areas

In this study, five representative urban vitality complexes in China's first tier and new first tier cities that have been successfully renovated and put into use in recent years were selected as study areas, including Xidan Renewal Field and Qianmen Beijing Fun in Beijing, Xintiandi in Shanghai, Beijing Road in Guangzhou, and Taikoo Li in Chengdu (Figure 1). All five complexes are renovated from existing buildings. Among them, the original built environment of Taikoo Li in Chengdu, Xintiandi in Shanghai, Beijing Road in Guangzhou, and Beijing Fun in Beijing belong to historical districts, while Xidan Renewal Field in Beijing was transformed from a traditional commercial district in the 1980s. Although the characteristics of the original sites are different, the design and construction of the five vibrant complexes all paid attention to small-scale details of the built environment during the renewal. They broke through the traditional function-oriented design methods and began to explore how to enhance the comprehensive vitality of the built environment by satisfying people's advanced emotional demands. At present, they are popular check-in places in their cities, and these vibrant spaces make them more attractive, even during the onslaught of virtual space in the digital age, providing people with various emotional experiences. These make them typical examples of this study. The basic conditions and characteristics of built environment of each complex are as follows (Table 1).

Table 1. Overview of the basic conditions and characteristics of the five urban renewal complexes.

City	City Level	Name of Complex	Renovation Period	Characteristics of the Original Built Environment	Characteristics of the Redeveloped Built Environment
Beijing	First tier	Beijing Fun	2006–2017	Dashilar historical and cultural protection area, hutong texture with traditional buildings built during the Republic of China	Restoring original city texture and several old buildings, using traditional material for new buildings and landscape.
Beijing	First tier	THE NEW Xidan Renewal Field	2014–2021	Traditional underground commercial space for low-quality small commodities, the space was cramped and there was no greenery.	A vibrant urban complex that integrates urban green space with high-quality trendy commercial space. The above-ground part has been upgraded into an urban park and returned to the public.
Shanghai	First tier	Xintiandi (Shikumen area)	1998–2001	Buildings in the 19-century Shikumen-style of cover 128 acres in the center of Shanghai, including the Former Residence of President Sun Yat Sen and several wealthy international settlements.	A mixture of old building styles, materials with diversified modern business formats. Each building exhibits its own unique international mix of styles. Some are more Chinese, and some are more Western.
Guangzhou	First tier	Beijing Road	2018–2020	Beijing Road Pedestrian Street is the central axis of Guangzhou that has not been offset for more than 2200 years. It has always been a prosperous commercial place and is known as "Lingnan First Street". It contains thousands of years of commercial architectural remains, including historic Lingnan buildings, archways, and street paving, as well as traditional modern commercial buildings.	The redevelopment of Beijing Road integrates historical buildings, contemporary diversified business formats and 5G interactive technology. The updated vitality space restores 376 arcade buildings and 8840 square meters of main street building facades, and with the help of digital technology to create immersive experience spaces.

Table 1. *Cont.*

City	City Level	Name of Complex	Renovation Period	Characteristics of the Original Built Environment	Characteristics of the Redeveloped Built Environment
Chengdu	New first tier	Taikoo Li	2008–2014	Adjacent to the ancient Daci Temple and Chunxi Road commercial area, there were five historical buildings and many historical streets.	Taikoo Li represents an open-plan low-rise shopping mall, which takes on a traditional architecture style accomplished by a pioneering modern approach. Six traditional courtyards and building lie within, adding to its historical image. It is a new dynamic cultural and commercial landmark, and reinvigorates the townscape of Chengdu.



Figure 1. Location and features of the five urban renewal complexes [82–87]. (**b**,**d**,**l**,**m**) are photographed by the author.

2.2. Data Sources

According to the research appeal, the emotional attachment scale was chosen and constructed based on emotional attachment theories, and the research team used the scale to measure the dimension, degree, and intensity of emotional attachment between people and the built environment in the above five complexes from May to July 2022. The research team was divided into five groups to do on-site study during the same time period. Among them, there were 2 volunteer researchers each in Beijing Fun and THE NEW Xidan Renewal Field in Beijing, and 3 volunteer researchers each in Shanghai Xintiandi, Chengdu Taikoo Li, and Guangzhou Beijing Road. To ensure the comparability of the data, young people around 20 to 30 years old were randomly selected in each of the five complexes to fill out a semi-structured scale. Finally, the number of effective scales collected in the five complex areas were: 196 in Beijing Fun in Beijing, 184 in THE NEW Xidan Renewal Field in Beijing, 152 in Xintiandi in Shanghai, 155 in Beijing Road in Guangzhou, and 174 in Taikoo Li in Chengdu.

2.3. Build a Methodology

2.3.1. The Construction of Emotional Attachment Scale and Indicators of Evaluation Index

To explore the dimension and degree of people's emotional attachment to five renewal urban vitality areas, and the attachment intensity of specific built environment characteristics, the place attachment scale, PANAS scale, and a newly-constructed and tested scale of attachment intensity for specific built environment characteristics were combined in the study. The reliability and validity of the scales have been confirmed by a series of domestic and foreign built environment studies [8,44,50,88], so the characteristics are also used as indicators for the evaluation of emotional attachment characteristics of the vitality spaces.

In order to explore different emotional attachment features according to different perspectives and research demands, multidisciplinary researchers constructed a series of scales. Among them, Scannell and Gifford proposed a tripartite organizing framework or person-process-place (PPP), based on previous studies, to explain attachment mechanisms, and constructed the related place attachment scale [40]. As the PPP PA scale emphasizes the importance of the built environment in the attachment process, it met the aim of our study both in content and practicality, and was adjusted as a part of the scales to measure attachment degree in the study. Additionally, the positive and negative analysis scale (PANAS) was used to explore people's attachment to the five vitality complexes in the study [41]. In order to avoid a cultural gap and improve the clarity of the scale, a Chinese version of the above two scales was revised. The last part of the scales aimed to explore the effect of specific characteristics of the built environment, while also serving as indicators during the evaluation process. Based on the features of the five complexes and the appeal of this study, the physical, social, and interactive characteristics that constitute the built environment indicators include: material, color, natural elements, form and structure, privacy, diversity, sociability, territoriality, playability, uniqueness, and changeability. The Likert scale was used to quantitatively measure intensity, with a score of 1 indicating almost no emotional attachment to this indicator and a score of 7 indicating a strong emotional attachment. SPSS 25.0 (International Business Machines Corporation (IBM), IBM headquarters in Almonk, New York, NY, USA) was used to process the data collected by these scales, including their basic characteristics representing comprehensive degree and intensity of attachment, which made up the indicators of evaluation. Additionally, the correlation between attachment, positive and negative affect, and specific built environment characteristics was also explored using a correlation analysis (Pearson) using SPSS. The former results of each indicator were then used in the following evaluation process to rank the five complexes, and the results were further analyzed integrating the latter correlation analysis results.

2.3.2. The Evaluation Method of Improved TOPSIS Combining Entropy Weight and Grey Relational Analysis

The evaluation of the degree and intensity of people's emotional attachment to a particular urban vitality space depends on the established scale and evaluation index. Although the reliability and validity of the above scales have been confirmed in relevant studies [8,44,50,89], the subjectivity of researchers and designers—and certain objective reasons, such as the imperfections and differences in the scale data—could still lead to uncertainty in the evaluation process to some extent, which may influence the accuracy of an emotional attachment evaluation of urban vitality spaces.

To deal with this uncertainty in the evaluation system and the problems it brings, an improved TOPSIS method with entropy method (EW) to assign weights to the above indicators based on their scores, and grey relation analysis (GRA) to reduce uncertainty was applied in assessing numerical values [69,90,91]. The improved method is hoped to enhance the objectivity of the attachment evaluation of this study.

1. Entropy Weight Method: Determining the Weight of Indicators

Using the entropy weight method instead of the Delphi method or athenalytic hierarchy process when determining the weight of the evaluation indicators helps to overcome subjectivity in the traditional TOPSIS method. It is more objective, especially when interrelated objects are evaluated at the same time. This combination has been successfully applied by many researchers in the evaluation of urban space and related studies, thereby avoiding a certain degree of subjectivity bias. This study needed to evaluate emotional attachment to multiple urban vitality complexes in multiple cities, therefore there is a close relation between these complexes and cities. Therefore, the EW method was used to determine the weight of indicators. The main steps are as follows.

Step 1: there are m urban vitality complexes to be evaluated and n built environment-related evaluation indicators for each urban complex in this study, and the nth analysis indicator of the m evaluation objects is marked as a_{ij} ($1 \le i \le m$, $1 \le j \le n$), and the judgment matrix $A = (a_{ij})_{m \times n}$ is expressed as:

$$A = \begin{pmatrix} a_{11} & \cdots & a_{1n} \\ \vdots & \ddots & \vdots \\ a_{m1} & \cdots & a_{mn} \end{pmatrix} \quad (1)$$

where a_{ij}, i = 1,2, … ,m, j = 1,2, … ,n is the j-th indicator of the i-th urban vitality complex; m = 5, n = 14 in this paper.

Step 2: the judgment matrix $A = (a_{ij})_{m \times n}$ is standardized according to the 0–1 transformation, and the standardized matrix $A' = (a'_{ij})_{m \times n}$.

$$A' = \begin{pmatrix} a'_{11} & \cdots & a'_{1n} \\ \vdots & \ddots & \vdots \\ a'_{m1} & \cdots & a'_{mn} \end{pmatrix} \quad (2)$$

In this study, the negative affect is a negative indicator, while all other affects are positive indicators. Positive indicators are preprocessed using Equation (3), and negative indicators are preprocessed using Equation (4).

$$\begin{aligned} a'_{ij} &= \frac{a_{ij} - \min\limits_i a_{ij}}{\max\limits_i a_{ij} - \min\limits_i a_{ij}} \max\limits_i a_{ij} \neq \min\limits_i a_{ij} \\ a'_{ij} &= 1 \max\limits_i a_{ij} = \min\limits_i a_{ij} \end{aligned} \quad (3)$$

$$\begin{aligned} a'_{ij} &= \frac{\max\limits_i a_{ij} - a_{ij}}{\max\limits_i a_{ij} - \min\limits_i a_{ij}} \max\limits_i a_{ij} \neq \min\limits_i a_{ij} \\ a'_{ij} &= 1 \max\limits_i a_{ij} = \min\limits_i a_{ij} \end{aligned} \tag{4}$$

Step 3: calculate the proportion p_{ij} of the i-th urban vitality complex in the j-th indicator, the formula is as follows:

$$p_{ij} = \frac{a\prime_{ij}}{\sum\limits_{i=1}^{m} a\prime_{ij}}, i = 1, 2, \cdots, m;\ j = 1, 2, \cdots, n \tag{5}$$

Step 4: calculate the entropy value E_j of each indicator, the formula is as follows:

$$E_j = -k \sum_{i=1}^{m} p_{ij} \ln p_{ij},\ j = 1, 2, \cdots, n \tag{6}$$

where $k = \frac{1}{\ln m}$, $0 \leq E_j \leq 1$.

Step 5: calculate the weight of each indicator. The information entropy redundancy d_j is calculated by the following formula:

$$d_j = 1 - E_j, j = 1, 2, \cdots, n \tag{7}$$

Based on the information entropy redundancy d_j, calculate the weight ω_j of the j-th indicator, and the formula is as follows:

$$\omega_j = \frac{d_j}{\sum\limits_{j=1}^{n} d_j}, j = 1, 2, \cdots, n \tag{8}$$

In this paper, according to the index values of 14 evaluation indicators in the emotional attachment evaluation index system of 5 urban vitality complexes in 4 Chinese first tier and new first tier cites, the weight of each indicator was calculated according to the above steps of the EW method.

2. Improved TOPSIS Method with GRA (Grey Relation Analysis)

Considering the diversity of the emotional attachment indicators, their quantitative evaluation turns out to be a typical MADM (multi-attribute decision-making) problem. Therefore, the study adopted the TOPSIS method to comprehensively evaluate attachment. Additionally, as there was correlation between various indicators, the grey relation analysis was introduced to improve the TOPSIS method, which helped to intuitively show the nonlinear relationship between sequences. The calculation process of the improved TOPSIS method is as follows. First, the positive ideal solution and negative ideal solution of emotional attachment to urban vitality complexes are determined through traditional TOPSIS. Second, GRA is used to compare the scores of the evaluation indicators of each complex respectively with the positive and negative ideal solutions. Third, the grey relational degree between complexes is determined. Last but not least, the emotional attachment intensity of each complex is ranked according to the results. The steps are as follows:

Step 1: standardize the matrix $A = \left(a_{ij}\right)_{m \times n}$ to get a standardized matrix $X = \left(x_{ij}\right)_{m \times n}$, where x_{ij} is calculated as follows:

$$x_{ij} = \frac{a\prime_{ij}}{\sqrt{\sum\limits_{i=1}^{m} a\prime_{ij}{}^2}}, 1 \leq i \leq m, 1 \leq j \leq n \tag{9}$$

Step 2: the weight vector $\omega_j = (\omega_1, \omega_2, \ldots, \omega_j \ldots \omega_n)$ obtained in Equation (8) is multiplied by the standardization matrix $X = (x_{ij})_{m \times n}$ to get a weighted standardization matrix as follows:

$$Y = \begin{pmatrix} \omega_1 x_{11} & \omega_2 x_{12} & \ldots & \omega_n x_{1n} \\ \omega_1 x_{21} & \omega_2 x_{22} & \ldots & \omega_n x_{2n} \\ \vdots & \vdots & \ldots & \vdots \\ \omega_1 x_{m1} & \omega_2 x_{m2} & \cdots & \omega_n x_{mn} \end{pmatrix} = \begin{pmatrix} y_{11} & y_{12} & \ldots & y_{1n} \\ y_{21} & y_{22} & \ldots & y_{2n} \\ \vdots & \vdots & \ldots & \vdots \\ y_{m1} & y_{m2} & \cdots & y_{mn} \end{pmatrix} \tag{10}$$

Step 3: the positive ideal solution y^+ and negative ideal solution y^- is calculated as follows, where J^+ is the set of positive indicators while J^- is the set of negative indicators:

$$y^+ = \left[\left(\max_{1 \le i \le m} y_{ij} \middle| j \in J^+ \right), \left(\min_{1 \le i \le m} y_{ij} \middle| j \in J^- \right) \right] = \left({y_1}^+, {y_2}^+, \cdots, {y_m}^+ \right) \tag{11}$$

$$y^- = \left[\left(\min_{1 \le i \le m} y_{ij} \middle| j \in J^+ \right), \left(\max_{1 \le i \le m} y_{ij} \middle| j \in J^- \right) \right] = \left({y_1}^-, {y_2}^-, \cdots, {y_m}^- \right) \tag{12}$$

Specifically, the positive ideal solution represents a fictitious plan which, in this paper, means a fictitious urban vitality complex whose ability to promote emotional attachment is best, and the emotional attachment intensity is the highest. The negative ideal solution is the worst plan which, in this paper, means a fictitious urban vitality complex whose ability to promote emotional attachment is worst, and the emotional attachment intensity is the lowest.

Step 4: calculation of distance between each complex and the positive ideal solution r_i^+ and the negative ideal solution r_i^-. $r_i^+(r_i^-)$ is the Euclidean distance, of which a lower $r_i^+(r_i^-)$ indicates that the complex is closer to the positive (negative) ideal solution, while the emotional attachment intensity is higher (lower).

$$r_i^+ = \sqrt{\sum_{j=1}^{n} \left[\left(y_{ij} - y_j^+ \right) \right]^2}, \ 1 \le i \le m, 1 \le j \le n \tag{13}$$

$$r_i^- = \sqrt{\sum_{j=1}^{n} \left[\left(y_{ij} - y_j^- \right) \right]^2}, \ 1 \le i \le m, 1 \le j \le n \tag{14}$$

Step 5: calculation of the grey relational degree:

$$h_{ij}^+ = \frac{\min\limits_i \min\limits_j \left| y^+ - y_{ij} \right| + \rho \max\limits_i \max\limits_j \left| y^+ - y_{ij} \right|}{\left| y^+ - y_{ij} \right| + \rho \max\limits_i \max\limits_j \left| y^+ - y_{ij} \right|} \tag{15}$$

$$h_{ij}^- = \frac{\min\limits_i \min\limits_j \left| y^- - y_{ij} \right| + \rho \max\limits_i \max\limits_j \left| y^- - y_{ij} \right|}{\left| y^- - y_{ij} \right| + \rho \max\limits_i \max\limits_j \left| y^- - y_{ij} \right|} \tag{16}$$

$$h_i^+ = \frac{1}{n} \sum_{j=1}^{n} h_{ij}^+, \ 1 \le i \le m \tag{17}$$

$$h_i^- = \frac{1}{n} \sum_{j=1}^{n} h_{ij}^-, \ 1 \le i \le m \tag{18}$$

where $\rho = 0.5$, h_i^+ is the grey correlation degree between the evaluation indicators and positive ideal solution, h_i^- is the grey correlation degree between the evaluation indicators and negative ideal solution.

Step 6: dimensionless processing weighted the distances r_i^+ and r_i^-, and the grey correlation h_i^+ and h_i^-:

$$R_i^+ = \frac{\max r_i^+ - r_i^+}{\max r_i^+ - \min r_i^+},\ 1 \le i \le m \tag{19}$$

$$R_i^- = \frac{\max r_i^- - r_i^-}{\max r_i^- - \min r_i^-},\ 1 \le i \le m \tag{20}$$

$$H_i^+ = \frac{\max h_i^+ - h_i^+}{\max h_i^+ - \min h_i^+},\ 1 \le i \le m \tag{21}$$

$$H_i^- = \frac{\max h_i^- - h_i^-}{\max h_i^- - \min h_i^-},\ 1 \le i \le m \tag{22}$$

Step 7: integrate the above results of the dimensionless distance and the dimensionless grey relational degree:

$$Z_i^+ = \alpha R_i^- + \beta H_i^+,\ 1 \le \mathrm{i} \le \mathrm{m} \tag{23}$$

$$Z_i^- = \alpha R_i^+ + \beta H_i^-,\ 1 \le \mathrm{i} \le \mathrm{m} \tag{24}$$

where Z_i^+ (Z_i^-) represents the comprehensive relation between complex A_i and the positive (negative) ideal solution. $\alpha + \beta = 1$, $\alpha > 0$, $\beta > 0$.

Step 8: calculation of the relative closeness C_i^+ of the urban vitality complex $A_i = (i = 1, 2, \cdots, m)$

$$C_i^+ = \frac{Z_i^+}{Z_i^- + Z_i^+},\ 1 \le i \le m \tag{25}$$

The higher the C_i^+ is, complex A_i is closer to the positive ideal solution, which means that its ability to promote emotional attachment is best, while the emotional attachment intensity is the highest. Then, each complex can acquire its relative closeness and this indicator can be used to rank the emotional attachment level of the urban vitality complex.

2.3.3. Methodology Framework

Figure 2 illustrates the framework of this study. The study focuses on the emotional attachment analysis and evaluation of small-scale built environment characteristics of urban vitality complexes, and is based on the measurement of attachment degree, dimension, and intensity, with the help of emotional attachment theory. It adopts the logical path of "criteria establishment-methodology construction-results processing" to evaluate the emotional attachment of vibrant urban complexes, while comprehensively analyzing the value of specific built environment characteristics with the results of scale analysis.

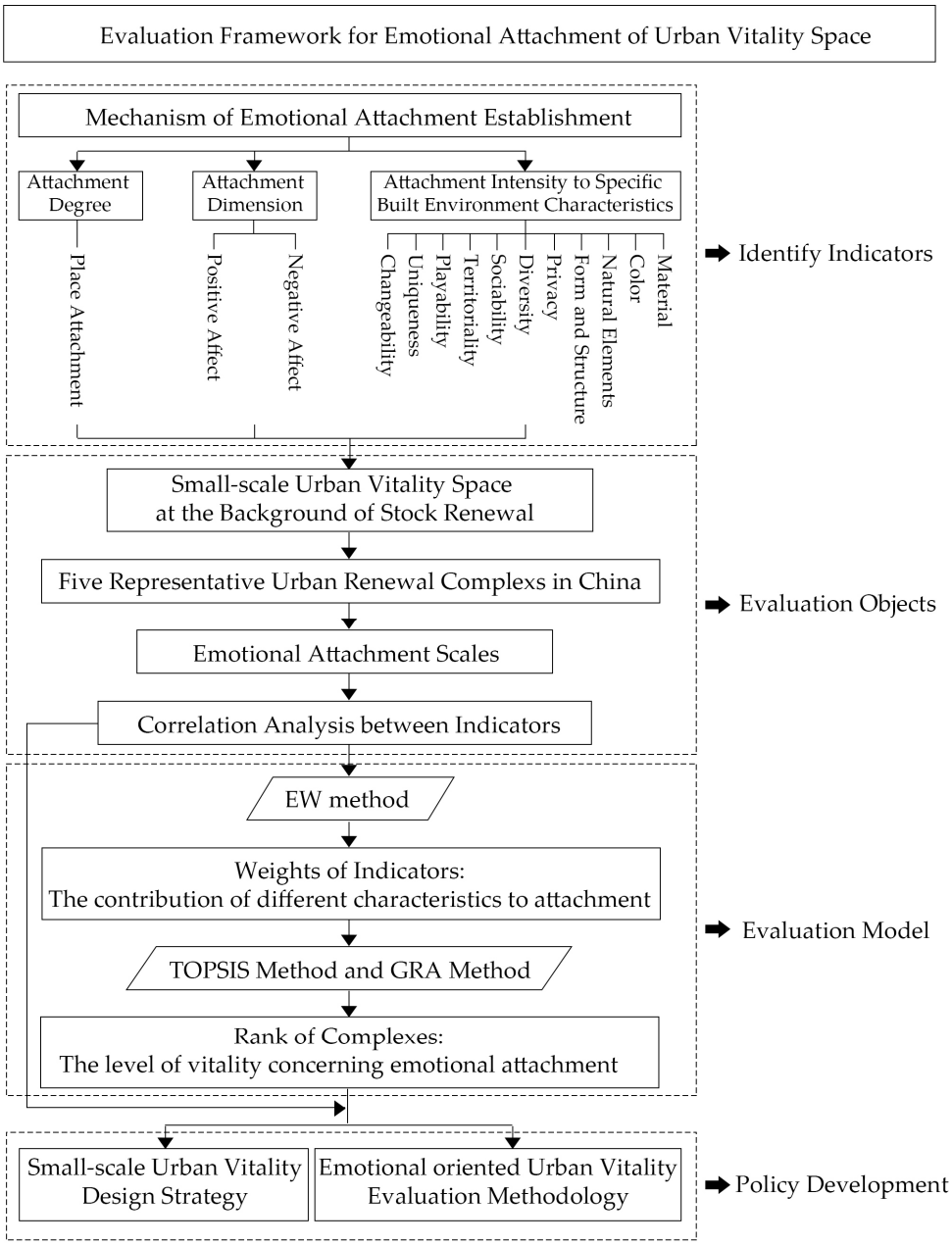


Figure 2. Flowchart of the proposed framework.

3. Results

3.1. The Results of Calculation and Analysis of Emotional Attachment Scale and Emotional Attachment Evaluation Indicators

3.1.1. Calculation Results of Emotional Attachment Indicators of the Five Complexes

The overall data of each emotional attachment indicator of the five complexes is listed in Table 2. As for attachment degree, the results showed that people generally established a relatively strong emotional attachment to all five urban vitality complexes, as their average degree all exceeded their mean value, while the value of standard deviation indicated that this attachment degree was quite different between different people. As for attachment dimension, in all five complexes, the positive affect obtained by people was more pronounced than the negative affect, based on their mean value, and the value of standard deviation showed that people almost felt the same way in these complexes. As for people's attachment intensity to specific built environment characteristics, the results of mean value showed that people generally have a strong emotional experience of the

characteristics of the built environment, which once again proves the emotion-induced value of the specific characteristics of the built environment. The above indicators from the attachment scale form the index system of the emotional attachment evaluation, based on the EW-GRA-TOPSIS method.

Table 2. Results of emotional attachment indicators of the five complexes.

Emotional Attachment Index		Beijing Fun		THE NEW Xidan Renewal Field		Xintiandi (Shikumen Area)		Beijing Road		Taikoo Li	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Attachment Degree	Place Attachment	3.95	1.01	3.92	0.88	3.84	1.03	3.81	0.95	3.99	1.08
Attachment Dimension	Positive Affect	2.29	0.72	2.41	0.70	1.97	0.42	2.00	0.66	2.43	0.86
	Negative Affect	1.24	0.31	1.19	0.34	1.05	0.12	1.19	0.29	1.35	0.53
Attachment intensity to specific built environment characteristic	Material	4.98	1.46	4.89	1.56	5.56	1.15	4.78	1.22	5.01	1.42
	Color	5.08	1.40	5.47	1.23	5.40	1.12	4.84	1.22	5.34	1.27
	Natural Elements	4.61	1.67	4.85	1.63	4.78	0.97	4.5	1.27	4.93	1.66
	Form and Structure	5.29	1.41	5.50	1.19	5.22	1.07	4.8	1.12	5.53	1.30
	Privacy	3.88	1.58	4.15	1.58	3.60	0.76	4.2	4.61	4.41	1.59
	Diversity	5.08	1.46	5.27	1.37	5.44	1.09	4.06	1.71	5.46	1.41
	Sociability	4.74	1.63	5.13	1.37	4.92	1.24	4.76	1.33	5.31	1.56
	Territoriality	4.79	1.39	4.58	1.59	6.04	0.92	5.16	1.25	5.03	1.61
	Playability	4.13	1.39	4.43	1.49	4.68	1.38	3.98	1.76	4.07	1.70
	Uniqueness	4.79	1.46	5.13	1.29	5.86	1.13	4.74	1.23	5.43	1.39
	Changeability	4.33	1.53	4.96	1.44	4.94	1.33	3.84	1.74	5.03	1.49

3.1.2. Calculation Results of Correlation Analysis of Five Complexes

The correlation analysis was processed to further explore the extent to which each specific built environment characteristic contributed to the degree and dimension of emotional attachment. The results of the five complexes are shown in Tables 3–7. It is evident that people's attachment to all five complexes was positively correlated with positive affect (0.641 **, 0.401 **, 0.914 **, 0.479 **, 0.656 **). Regarding the calculation results of detailed characteristics, they were overall positively correlated with emotional attachment in five complexes. The results describing the material characteristics of the built environment—including material, color, nature-related features, and form and structure—of all five complexes were significantly positively correlated with place attachment, as they all have a relatively high correlation coefficient at 0.01 (double-tailed). This demonstrates the value of the built environment of the urban vitality complex with respect to emotional attachment. The results describing the social and interactive characteristics of the vitality complexes—including privacy, diversity, sociability, territoriality, playability, uniqueness and changeability—had positively affected emotional attachment, but different indicators reflected different effects on emotional attachment in different complexes. For example, the indicator playability correlated weaker with attachment in Beijing Fun and Xintiandi than the other three complexes, which might be due to their vibrant spaces, which were created on the basis of preserving the original, traditional hutong spaces, and the historical style of the city block. The indicator privacy correlated weakest with attachment in Beijing Road in Guangzhou (0.128 *). This might be directly related to its rectilinear spatial form, which lacked a wrapped space that provided a sense of privacy. In addition, the indicator sociability correlated weakest with attachment in Xintiandi in Shanghai among the five complexes (0.135 *). Combined with local observations and interviews, it could be inferred that this might be due to the narrow, linear street space, which dominates the form of the Xintiandi complex, while lacking open square nodes for staying and socializing. Furthermore, the correlation between different built environment characteristics

was analyzed to further understand the interaction and association between different built environment characteristics in the process of establishing emotional attachment. For example, the results showed that material and color were closely correlated with each other in all five complexes (0.726 **, 0.718 **, 0.599 **, 0.747 **, 0.800 **), which proved that, in the design and construction of these urban vitality complexes, the color of the material had an additive effect on people's emotional attachment. More detailed results could be used to help interpret the evaluation results in the following article, especially from the perspective of vibrant spaces design and construction.

Table 3. Correlation coefficients between different attachment indicators of Beijing Fun.

		1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	**Place Attachment**	1													
2	**Positive Affect**	0.641 **	1												
3	**Negative Affect**	−0.070	0.150	1											
4	**Material**	0.419 **	0.330 **	−0.104	1										
5	**Color**	0.478 **	0.380 **	−0.135	0.726 **	1									
6	**Natural Elements**	0.444 **	0.382 **	−0.127	0.396 **	0.390 **	1								
7	**Form and Structure**	0.525 **	0.406 **	−0.068	0.513 **	0.526 **	0.478 **	1							
8	**Privacy**	0.308 **	0.206 *	−0.045	0.289 **	0.322 **	0.323 **	0.375 **	1						
9	**Diversity**	0.465 **	0.372 **	−0.099	0.400 **	0.342 **	0.345 **	0.555 **	0.351 **	1					
10	**Sociability**	0.457 **	0.431 **	0.036	0.268 **	0.304 **	0.327 **	0.375 **	0.196 *	0.463 **	1				
11	**Territoriality**	0.383 **	0.362 **	−0.055	0.314 **	0.354 **	0.332 **	0.307 **	0.209 *	0.342 **	0.444 **	1			
12	**Playability**	0.266 **	0.230 *	−0.142	0.253 **	0.352 **	0.162	0.269 **	0.104	0.328 **	0.428 **	0.156	1		
13	**Uniqueness**	0.571 **	0.360 **	−0.186 *	0.553 **	0.537 **	0.427 **	0.536 **	0.316 **	0.390 **	0.278 **	0.378 **	0.437 **	1	
14	**Changeability**	0.437 **	0.315 **	−0.027	0.328 **	0.375 **	0.296 **	0.445 **	0.263 **	0.460 **	0.323 **	0.174	0.387 **	0.602 **	1

*. $p < 0.05$ (2-tailed), **. $p < 0.01$ (2-tailed).

Table 4. Correlation coefficients between different attachment indicators of THE NEW Xidan Renewal Field.

		1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	**Place Attachment**	1													
2	**Positive Affect**	0.401 **	1												
3	**Negative Affect**	−0.201 *	0.205 *	1											
4	**Material**	0.494 **	0.272 **	−0.162	1										
5	**Color**	0.571 **	0.224 *	−0.135	0.718 **	1									
6	**Natural Elements**	0.461 **	0.264 **	−0.096	0.584 **	0.561 **	1								
7	**Form and Structure**	0.515 **	0.156	−0.272 **	0.556 **	0.658 **	0.524 **	1							
8	**Privacy**	0.459 **	0.236 **	−0.273 **	0.639 **	0.480 **	0.562 **	0.484 **	1						
9	**Diversity**	0.546 **	0.239 **	−0.176	0.485 **	0.478 **	0.464 **	0.484 **	0.433 **	1					
10	**Sociability**	0.500 **	0.360 **	−0.004	0.402 **	0.387 **	0.350 **	0.462 **	0.311 **	0.533 **	1				
11	**Territoriality**	0.546 **	0.447 **	−0.021	0.441 **	0.408 **	0.464 **	0.335 **	0.444 **	0.461 **	0.506 **	1			
12	**Playability**	0.489 **	0.389 **	0.018	0.544 **	0.356 **	0.472 **	0.309 **	0.428 **	0.361 **	0.498 **	0.544 **	1		
13	**Uniqueness**	0.368 **	0.119	−0.194 *	0.487 **	0.344 **	0.313 **	0.348 **	0.485 **	0.429 **	0.425 **	0.395 **	0.490 **	1	
14	**Changeability**	0.455 **	0.263 **	0.035	0.393 **	0.460 **	0.405 **	0.400 **	0.404 **	0.408 **	0.525 **	0.434 **	0.369 **	0.553 **	1

*. $p < 0.05$ (2-tailed), **. $p < 0.01$ (2-tailed).

Table 5. Correlation coefficients between different attachment indicators of Xintiandi (Shikumen).

		1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	**Place Attachment**	1													
2	**Positive Affect**	0.914 **	1												
3	**Negative Affect**	−0.887 **	0.981 **	1											
4	**Material**	0.420 **	0.464 **	0.473 **	1										
5	**Color**	0.525 **	0.521 **	0.538 **	0.599 **	1									
6	**Natural Elements**	0.416 **	0.472 **	0.488 **	0.460 **	0.417 **	1								
7	**Form and Structure**	0.547 **	0.465 **	0.438 **	0.611 **	0.534 **	0.281 *	1							
8	**Privacy**	0.361 *	0.268	0.213	0.075	0.048	0.404 **	0.261	1						
9	**Diversity**	0.311 *	0.261	0.288 *	0.305 *	0.419 **	0.323 *	0.386 **	0.094	1					
10	**Sociability**	0.035	0.004	0.036	−0.326 *	−0.050	−0.049	−0.109	0.139	0.162	1				
11	**Territoriality**	0.250	0.313 *	0.338 *	0.229	0.377 **	0.146	0.217	−0.093	0.326 *	0.163	1			
12	**Playability**	0.307 *	0.420 **	0.398 **	0.258	0.308 *	0.190	0.255	0.090	0.164	0.271	0.651 **	1		
13	**Uniqueness**	0.437 **	0.480 **	0.520 **	0.347 *	0.529 **	0.418 **	0.330 *	−0.043	0.417 **	0.211	0.751 **	0.708 **	1	
14	**Changeability**	0.308 *	0.281 *	0.293 *	0.130	0.275	0.304 *	0.152	0.219	0.201	0.404 **	0.483 **	0.535 **	0.539 **	1

*. $p < 0.05$ (2-tailed), **. $p < 0.01$ (2-tailed).

Table 6. Correlation coefficients between different attachment indicators of Beijing Road.

		1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	**Place Attachment**	1													
2	**Positive Affect**	0.479 **	1												
3	**Negative Affect**	0.192	0.179	1											
4	**Material**	0.524 **	0.192	−0.114	1										
5	**Color**	0.394 **	0.185	−0.073	0.747 **	1									
6	**Natural Elements**	0.467 **	0.150	0.008	0.616 **	0.503 **	1								
7	**Form and Structure**	0.582 **	0.238	0.103	0.638 **	0.721 **	0.459 **	1							
8	**Privacy**	0.128 *	0.016	−0.028	0.259	0.180	0.269	0.185	1						
9	**Diversity**	0.516 **	0.497 **	0.154	0.625 **	0.446 **	0.590 **	0.368 **	0.203	1					
10	**Sociability**	0.558 **	0.522 **	0.267	0.495 **	0.252	0.435 **	0.389 **	0.061	0.643 **	1				
11	**Territoriality**	0.457 **	0.047	−0.020	0.399 **	0.205	0.296 *	0.342 *	0.214	0.167	0.378 **	1			
12	**Playability**	0.388 **	0.468 **	0.137	0.571 **	0.352 *	0.418 **	0.349 *	0.351 *	0.668 **	0.556 **	0.159	1		
13	**Uniqueness**	0.413 **	0.304 *	0.163	0.344 *	0.341 *	0.414 **	0.420 **	0.237	0.398 **	0.523 **	0.520 **	0.510 **	1	
14	**Changeability**	0.493 **	0.524 **	0.254	0.368 **	0.093	0.453 **	0.244	0.200	0.532 **	0.704 **	0.368 **	0.640 **	0.544 **	1

*. $p < 0.05$ (2-tailed), **. $p < 0.01$ (2-tailed).

Table 7. Correlation coefficients between different attachment indicators of Taikoo Li.

		1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	**Place Attachment**	1													
2	**Positive Affect**	0.656 **	1												
3	**Negative Affect**	0.096	0.302 **	1											
4	**Material**	0.450 **	0.309 **	−0.118	1										
5	**Color**	0.369 **	0.150	0.081	0.800 **	1									
6	**Natural Elements**	0.421 **	0.238 *	−0.027	0.641 **	0.646 **	1								
7	**Form and Structure**	0.450 **	0.197	0.100	0.577 **	0.729 **	0.565 **	1							
8	**Privacy**	0.390 **	0.321 **	−0.159	0.332 **	0.324 **	0.448 **	0.235 *	1						
9	**Diversity**	0.501 **	0.297 *	0.056	0.395 **	0.447 **	0.401 **	0.497 **	0.449 **	1					
10	**Sociability**	0.581 **	0.429 **	0.119	0.165	0.243 *	0.289 *	0.338 **	0.396 **	0.533 **	1				
11	**Territoriality**	0.501 **	0.428 **	0.160	0.365 **	0.449 **	0.462 **	0.550 **	0.354 **	0.381 **	0.459 **	1			
12	**Playability**	0.592 **	0.432 **	0.104	0.346 **	0.420 **	0.415 **	0.469 **	0.422 **	0.486 **	0.700 **	0.624 **	1		
13	**Uniqueness**	0.635 **	0.339 **	0.049	0.443 **	0.498 **	0.442 **	0.642 **	0.305 **	0.375 **	0.450 **	0.614 **	0.529 **	1	
14	**Changeability**	0.381 **	0.280 *	0.108	0.241 *	0.257 *	0.319 **	0.143	0.438 **	0.428 **	0.346 **	0.487 **	0.462 **	0.395 **	1

*. $p < 0.05$ (2-tailed), **. $p < 0.01$ (2-tailed).

3.2. The Results of the Emotional Attachment Evaluation of Urban Vitality Complexes Using EW-GRA-TOPSIS Method

Based on the index data from the five complexes collected and calculated above, the evaluation model of emotional attachment to the built environment of urban vitality complex established in Section 2.3 using the EW-GRA-TOPSIS method was applied to evaluate the emotional attachment level of the five complexes.

3.2.1. Calculation of the Weight of Each Indicator

The judgement matrix A is established, standardized, and normalized based on Equations (1)–(4). The entropy value E_j and weight ω_j of each indicator of the five complexes are calculated using Equations (5)–(8). The results are as follows (Table 8).

3.2.2. Calculation of the Positive and Negative Ideal Solution of Each Indicator

After standardizing and weighing judgement matrix A according to Equations (9) and (10), the positive and negative ideal solutions of each indicator are calculated using Equations (11) and (12). The results are as follows (Table 9).

Table 8. Weight of each indicator.

Evaluation Index	E_j	ω_j
Place Attachment	0.741	0.085
Positive Affect	0.734	0.087
Negative Affect	0.829	0.056
Material	0.713	0.094
Color	0.841	0.052
Natural Elements	0.820	0.059
Form and Structure	0.856	0.047
Privacy	0.836	0.054
Diversity	0.866	0.044
Sociability	0.694	0.100
Territoriality	0.743	0.084
Playability	0.720	0.092
Uniqueness	0.708	0.096
Changeability	0.843	0.052

Table 9. Positive ideal solution and negative ideal solution of each indicator.

Evaluation Index	Positive Ideal Solution	Negative Ideal Solution
Place Attachment	0.086	0.001
Positive Affect	0.088	0.001
Negative Affect	0.056	0.001
Material	0.095	0.001
Color	0.052	0.001
Natural Elements	0.060	0.001
Form and Structure	0.048	0.000
Privacy	0.054	0.001
Diversity	0.044	0.000
Sociability	0.101	0.001
Territoriality	0.085	0.001
Playability	0.093	0.001
Uniqueness	0.097	0.001
Changeability	0.052	0.001

3.2.3. Calculation of the Distance from the Emotional Attachment of Each Urban Vitality Complex to the Positive and Negative Ideal Solution

The distance between the emotional attachment of each urban vitality complex and the ideal solution are calculated and nondimensionalized using Equations (13), (14), (19), and (20). The results are as follows (Table 10).

Table 10. Distance from the emotional attachment of each complex to the positive and negative ideal solution.

Urban Vitality Complex	R_i^+	R_i^-
Beijing Fun	0.219	0.085
THE NEW Xidan Renewal Field	0.153	0.174
Xintiandi (Shikumen area)	0.127	0.231
Beijing Road	0.257	0.060
Taikoo Li	0.141	0.200

3.2.4. Calculation of Grey Relational Degree of Each Urban Vitality Complex

Based on the results of the calculation of positive (negative) solutions Section 3.2.2, the grey relational degree of each urban vitality complex is calculated and nondimensionalized using Equations (15), (18), (21), and (22). The results are as follows (Table 11).

Table 11. Grey relational degree of each complex.

Urban Vitality Complex	H_i^+	H_i^-
Beijing Fun	0.690	0.655
THE NEW Xidan Renewal Field	0.505	0.488
Xintiandi (Shikumen area)	0.464	0.468
Beijing Road	0.805	0.876
Taikoo Li	0.498	0.477

3.2.5. Calculation of the Relative Closeness and the Rank of Each Urban Vitality Complex

According to Equations (23) and (24), $Z_i{}^+$ and $Z_i{}^-$ are calculated and the relative closeness of each complex is obtained, based on Equation (25). Then, the emotional attachment level of each complex can be ranked. The results are shown as follows (Table 12).

Table 12. Relative closeness and the vitality evaluation rank of five complexes.

Urban Vitality Complex	Z_i^+	Z_i^-	C_i^+	Rank
Beijing Fun (in Beijing)	0.455	0.370	0.552	1
THE NEW Xidan Renewal Field	0.329	0.331	0.498	3
Xintiandi (Shikumen area)	0.296	0.350	0.458	5
Beijing Road (in Guangzhou)	0.531	0.468	0.532	2
Taikoo Li	0.320	0.339	0.486	4

The results show that Beijing Fun in Beijing ranks first in the five complexes, which means the level of emotional attachment it has established between people and the urban complex is the highest among the five complexes. Beijing Road in Guangzhou ranks second: its score of relative closeness is also high (0.532 > 0.5) and it is close to Beijing Fun. Xintiandi in Shanghai ranks last, which means that people have a relatively low emotional attachment to the built environment here; the reasons for this will be further analyzed in conjunction with the aforementioned correlation analysis, as well as local observation and interviews, in the next part.

4. Discussion

By surveying the progress of the emotional attachment evaluation of the built environment in the field of urban vitality-related researches in the literature, it is obvious that there are few studies focusing on the important role of the emotional attachment between people and the built environment in the design and construction of vibrant spaces. Additionally, the quantitative methods commonly used, such as data mining in urban vitality studies, are difficult to apply at the urban complex scale due to data limitations. A scientific gap exists both in theoretical and quantitative studies of emotional attachment that promote urban vitality. Therefore, this study, which focuses on the representative small-scale vibrant urban complexes in the background of stock renewal in China, attempts to improve existing urban vitality studies from the perspective of emotional attachment, and aims to exploit a quantitative method to achieve the objective and scientific evaluation of emotional attachment to urban vitality spaces. The results and methodology are discussed as follows.

4.1. The Value of Built Environment Characteristics in the Establishment of Emotional Attachment in Urban Vitality Spaces

According to the evaluation results, the built environment characteristics perform relatively better in the establishment of emotional attachment in Beijing Fun in Beijing and Beijing Road in Guangzhou, as they rank as the top two and both score over 0.5 (0.552, 0.532). These two urban vitality complexes are both built based on the renewal of traditional local historic districts. Combined with the results of the correlation analysis in Section 3.1.2, it is obvious that material, built environment characteristics in both complexes play an

important role in attachment. The form and structure of the two complexes are significantly correlated with attachment (0.525 **, 0.582 **), which means that traditional and historical space form play a major role in promoting attachment in this type of urban vitality space. The significant correlation between form and structure and material and color (Beijing Fun: 0.513 **, 0.526 **; Beijing Road: 0.638 **, 0.721 **) further indicates that old materials, such as reused old bricks, and their color provide people with an obvious emotional experience. This can also be confirmed by local observations and interviews, for example, lots of people preferred to stop and touch mottled, time-marked bricks and woods. As for the social and interactive characteristics of the two complexes, uniqueness plays a more important role in attachment to Beijing Fun (0.571 **) while diversity and sociability plays a more important role in the attachment to Beijing Road (0.516 **, 0.558 **). Combined with the correlation analysis results regarding specific characteristics, it can be inferred that the uniqueness of Beijing Fun is significantly related to its material, as well as its color, while the diversity and sociability of Beijing Road mainly come from its material and natural elements.

THE NEW Xidan Renewal Field in Beijing and Taikooli in Chengdu rank third and fourth in the evaluation, but their scores are very close to the first two complexes (0.498, 0.486). Combined with the correlation analysis results, it can be inferred that built environment characteristics in these two complexes also contribute a lot in terms of promoting emotional attachment. Specifically, material characteristics—including material, color, natural elements, and form and structure—perform better in Xidan Renewal Field than in Taikooli (Xidan Renewal Field: 0.494 **, 0.571 **, 0.461 **, 0.515 ** > Taikooli: 0.450 **, 0.369 **, 0.421 **, 0.450 **). To a certain extent, it proves that the new design materials and structures that respond to the demands of young people do indeed help Xidan Renewal Field to emerge in the surrounding Xidan traditional business districts, while Taikooli uses more traditional materials and special form for a new function.

Xintiandi in Shanghai ranks last in the emotional attachment evaluation of the five vitality complexes. According to the correlation analysis, material, built environment characteristics are significantly correlated with attachment, but social and interactive ones show less correlation. Among them, sociability and territoriality correlated weakest with attachment (0.035, 0.250), which shows almost no effect on people's emotion in Xintiandi. This is relatively unexpected, as the vitality of Xintiandi is closely related to the creation of social spaces. Combined with the interviews on site, it can be inferred that the results may be due to the emerging new complexes and urban vitality spaces around the old Xintiandi Shikumen area, as lots of interviewees showed more interest in the nearby newly built Social House and Xintiandi Fashion I & II.

In general, the characteristics of the built environment in the five complexes all play an important role in promoting emotional attachment, further promoting the creation of urban vitality. The difference in the role of specific characteristics in different complexes does not necessarily indicate that this feature has no effect on emotional vitality, but may be related to changes in society and the surrounding urban environment.

4.2. The Promotion of Quantification Methods in the Research and Evaluation of Small-Scale Urban Vitality Spaces

In the digital age, quantification methods for urban vitality studies are mostly presented as a series of big data methodologies, which are mainly used to explore large-scale areas as cities or wider regions. However, these methods, such as geographic databases and POIs, are useless when the study area is narrowed down to small-scale vibrant built environments, such as various buildings and complexes. Since the vitality of the small-scale space comes from the interaction between people and the specific characteristics of the built environment, and emotion is one of the cores of vitality formation, the quantitative measurement method of emotional attachment scale formed by multidisciplinary researchers provides quantification methods for small-scale vitality space analysis. This methodology uncovers potential information regarding built environment objects by revealing the role of specific built environment characteristics in the establishment of emotional attachment,

as well as their interrelationship, and finally produces data to more objectively and scientifically comprehend the mechanism by which the built environment works in terms of attachment to vibrant urban spaces. In the examination of urban vitality at small-scale, built environment, the emotional attachment approach is therefore exploited both as theoretical guidance and a quantitative tool.

Based on the results of attachment scale, the improved TOPSIS method was then used to further evaluate the relative level of emotional attachment of different vibrant complexes. The traditional TOPSIS model sets the weights of each indicator to be the same when calculating the score and normalizing, which always causes the result to deviate from the fact. Therefore, this study selects the EM method to alter the weight settings of the indicators from the attachment scale analysis, so that the weights assigned by different indicators conform better to the characteristics of the vitality complex. Additionally, the GRA method is combined to compensate for the inherent shortcomings of the single TOPSIS model. After the weight settings were established, the computed values of various built environment characteristics with the improved TOPSIS method were organized.

This method has the advantages of combining qualitative and quantitative analysis, not only taking into account the perceptual emotional needs of people for spatial characteristics in the small-scale vitality space evaluation, but also using accurate mathematical methods to quantify it, so that the evaluation results are clear at a glance, especially for the comparison of multiple urban vitality complexes, so as to provide a scientific, reasonable, and practical method for the evaluation and optimization of urban vitality space design, construction, and future commercial operation.

4.3. The Application of the Results of Emotional Attachment Evaluation of Urban Vitality Research

Generally speaking, emotional attachment scale and evaluation results make it difficult to show the characteristics of other built environments in other cities, due to their uniqueness. However, in terms of establishing emotional attachment through urban vitality construction in the context of China's stock renewal, there are obvious similarities in the design of urban vitality spaces, particularly with regard to renewal and renovation based on existing buildings and city blocks. Newly built, small-scale urban vitality spaces exhibit similarity in terms of built environment characteristics, which help promote attachment. Therefore, the results of this study regarding the specific value of each characteristic of urban vitality spaces can noticeably reflect the situation in similar urban complexes in other Chinese cities.

The approach proposed in this study quantifies the perceptual emotional attachment data into small-scale, built environment characteristic evaluation results of urban vitality spaces. The attachment scale and evaluation results help reveal the small-scale urban vitality elements which are closer to people's daily lives. There are both similarities and differences between large-scale urban vitality construction and small-scale urban vitality construction. For example, material characteristics—including material, color, natural elements, and form and structure—are an essential component of the vibrant built environment at the small-scale, from the perspective of emotional attachment, which are rarely seen in larger-scale vitality researches. Additionally, social and interactive characteristics–such as diversity, sociability, and territoriality—can be generalized to large-scale urban vitality researches. Spaces that promote sociability and have local characteristics can promote emotional attachment at multiple spatial scales, which thereby enhance spatial vitality. Additionally, although privacy shows significant positive correlation with attachment in small-scale vitality spaces, it has little impact on the overall vitality evaluation of the space. For example, Beijing Road in Guangzhou ranks second in the attachment evaluation, which indicates a high level of vitality based on emotional attachment. However, its privacy shows weak correlation with attachment, and almost no correlation with material, built environment characteristics.

Another crucial result of this exploration is the mechanism and promotion of specific built environment characteristics on the establishment of emotional attachment. For

example, for vibrant built environments designed and constructed based on the renovation and renewal of historic districts, such as Beijing Fun in Beijing and Beijing Road in Shanghai, the structure, form, and material chosen are closely related to historical and local characteristics. Based on place attachment theory, emotional attachment is established and reinforced through the identification of the exact place and its history under these circumstances. Additionally, during the establishment of attachment, material is always significantly correlated with color, form, and structure. It proves that revealing the texture and mechanical characteristics of the material itself in small-scale space design is conducive to emotional attachment, especially in the context of historical urban space renewal, thereby promoting its vitality.

Furthermore, the promotion of vitality of built environment also depends on carrying people's social interaction and activities, so the way its material characteristics are organized will significantly affect people's emotional experience and behavior. For example, for the evaluation's top two complexes of Beijing Fun and Beijing Road, the basic material spatial components—including material, form, and structure—all show significant positive correlation with their diversity, sociability, playability, uniqueness, and changeability. In Xintiandi (Shikumen) in Shanghai, which ranks last in the evaluation, the material characteristics of the built environment show weaker positive correlation with social and interactive ones, and sociability even shows a negative correlation with material, color, form, and structure.

In addition, the vitality of the space is constantly changing and developing, which may be influenced by time and society, as well as the development of the surrounding environment. Therefore, the evaluation results of vitality space based on emotional attachment need to be comprehensively judged and analyzed. For example, Xintiandi (Shikumen) ranks last in the evaluation of the study. However, its built environment characteristics has many similarities with the top two complexes, Beijing Fang and Beijing Road, and since its completion, it has even been recognized as a representative urban renewal vibrant complex worldwide. Combined with local observation and interviews, it can be inferred that the reason why its score is relatively low is mainly due to the update and iteration of the surrounding urban areas in recent years, as several newly built vibrant complexes that have emerged, such as Xintiandi I & II, which aims to attract young people. At this time, the scores of sociability, uniqueness, changeability, and other interactive items in the scale of the Shikumen area are undoubtedly lower, as participants in this study are almost youngsters.

In the future research and design of urban vitality spaces, especially at the small-scale, the methodology in this study can be replicated both in the design process, to explore the emotion attached built environment characteristics to specify the design strategy, and in the evaluation process, to quantitatively measure the vitality level concerning emotional attachment. The results can be employed as a reference for small-scale urban vitality space design and renovation, in order to create a built environment that truly cares for people's emotional experience, and thereby stimulating the long-term vitality of the space.

5. Conclusions

Stimulating spatial vitality by renovating existing buildings and urban spaces into diverse urban complexes is an important way to promote urban vitality in China's first-tier and new first-tier cities under the background of stock renewal. However, in the existing field of urban vitality research, there is a lack of design and evaluation methods for small-scale vibrant spaces at the research scale. Regarding research dimension, there is a lack of attention being paid to the advanced needs of people's emotional attachment to specific vibrant spaces. Therefore, addressing the problem of insufficient quantitative research on small-scale urban vitality spaces and the lack of attention to the emotional dimension in the study of vitality, this paper proposes a methodology suitable for the exploration and evaluation of small-scale urban vitality spaces, and takes five representative vibrant urban complexes in China's first and new first tier cities as cases to demonstrate the application

of this method set. Based on the above analysis of the experimental process and results, the major results of this study are summarized as follows:

(1) The basic material characteristics of the built environment play an important role in the stimulation and promotion of urban vitality, including materials, colors, forms, and structures. According to the results, it can be inferred that the mechanisms by which they promote urban vitality through emotional attachment are presented in two ways. The first is based on the disclosure of the essential characteristics of material, including the structural form designed, based on its mechanical properties, while respecting its own texture and color. In this way, people can understand the logic of space construction more clearly, even if they do not have architectural expertise. The intelligibility of the environment is the basis for the establishment of emotional attachment, which is conducive to the creation of vitality. The second is to closely relate the selection and use of these material elements to the environmental history, context, and unique character of the vibrant space. For urban vitality spaces and complexes based on the renovation and renewal of historic districts, when conditions permit, old materials and the original structure of houses can be creatively reused, thereby establishing emotional attachment and enhancing spatial vitality by providing people with place identity. For emerging new vibrant places that aim to create a more futuristic and personalized complex, representative materials and spatial structures can be selected according to their target clients, marketing strategy, business type, etc., so that spatial form itself becomes the source of urban vitality. In addition to the above characteristics, the natural elements also contribute to emotional attachment, as well as vitality. However, as the five complexes studied in the paper lack specific consideration for the design of natural environment, the relevant conclusions need to be further explored.

(2) The social and interactive characteristics of the built environment are the externalized presentation of vitality in urban vitality spaces, which can be reflected by the diversity and density of various human activities, including privacy, diversity, sociability, territoriality, playability, uniqueness, and changeability. According to the results, the above characteristics have a significant, positive correlation with attachment in the complexes with higher vitality evaluation scores, indicating that they play an important role in promoting the spatial vitality from the perspective of emotional attachment. Among them, sociability and territoriality show almost no correlation with attachment in the complex ranked last in the evaluation, which proves, from the opposite perspective, that the two are closely related to the level of vitality. Privacy has a certain influence on the vitality, but not a significant one, as its correlation coefficient score is relatively low in the results of Beijing Road, which ranks second in the vitality evaluation.

(3) This study shows that the improved TOPSIS method based on EW and GRA can successfully deal with the comprehensive research and evaluation of the built environment involving multiple interrelated factors. Among them, the intervention of EW in the weight determination stage overcomes the subjectivity and one-sidedness of traditional expert scoring, and the intervention of GRA in the result evaluation stage reduces the inherent defects of a single model. Additionally, the combination of place attachment theory and the improved TOPSIS method has promoted an update of the quantitative evaluation methodology concerning the emotional attachment between people and the built environment. On the one hand, this provides quantitative data for the study of urban vitality at small-scale spaces, and on the other hand, it also creates an opportunity for subsequent analysis combined with urban vitality data from large-scale spaces, such as cities and wider regions, in the future.

At present, with the development of emotion measurement technology and data mining technology, the breadth and depth of acquisition of emotional attachment data between people and built environments are constantly expanding. Additionally, the faster updated speed of open-source data in urban spaces at different scales makes it easier to

couple emotional data with spatial data for further analysis. Therefore, the methodology proposed in this study can be replicated in different urban vitality spaces in different cities to examine and compare its performance and make further improvements. On the one hand, in addition to the emotional attachment scale measurement method, multimodal attachment data acquisition technologies, such as wearable physiological data collection instruments, eye trackers, portable EEG acquisition instruments, etc., can be used to expand and improve the evaluation index. On the other hand, when the methodology is employed in different urban vitality spaces of different backgrounds and at different scales, the evaluation indicators of built environment characteristics and their weight setting should be adjusted according to the characteristics of the study area.

Generally speaking, the methodology constructed in this study is different from the existing urban vitality evaluation methods in terms of starting point and object scale. Theoretical basis and value orientation of the new method are both based on people's emotional experience in urban vitality spaces, aiming to find design and construction methods to enhance people's subjective emotional attachment to the environment through objective data analysis. Place attachment theory provides a bridge for quantitative translation of subjective emotions that are difficult to quantify, especially in small-scale spaces. By analyzing and evaluating emotional attachment data, the attachment degree and vitality level of the complexes especially their built environment is derived in a quantitative manner via this method. The research not only reveals the impact of the specific built environment characteristics of the urban vitality space on people's emotional experience in a more scientific and objective way, but also provides more humanistic ideas and references for the renewal, design, construction, and management of the future urban vitality space.

However, the application of this method in current research is only the beginning, and both its depth and breadth need to be expanded. On the one hand, the methodology can be replicated in multiple different small-scale urban vitality complexes in different cities in China to compare its performance, and the experimental results can be combined to supplement and improve the method. On the other hand, more emotional attachment indicators can be added with the help of updated emotional data collection and analysis techniques. This way, researchers can observe the influence of changes in indicators on attachment evaluation results and analyze the value of the new built environment characteristics of urban vitality spaces.

Funding: This research was funded by the National Natural Science Foundation of China (No. 52208005), Beijing Social Science Foundation (No. 22GLC063).

Data Availability Statement: Data supporting reported results can be found by contacting the authors upon reasonable request.

Acknowledgments: Thanks for Yao Gong and Yinjing Luo for their help of recruiting the team in four cities to help with the scale measurement. Thanks for Wenxu Xu, Xiling Wang, Ruoxi Yu, Zhiqing Zhang, Youxing Feng, Xingjian Yi, Jiayin Tan, Jiayu Zhang, Shihui Zhang, Yang Lu, Xingyu Peng for their help of distributing and collecting scales. Thanks for Yinjing Luo and Jiayu Zhang for their photography of Beijing Fun, Xidan Renewal Field and Taikoo Li.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Guo, X.; Chen, H.; Yang, X. An evaluation of street dynamic vitality and its influential factors based on multi-source big data. *ISPRS Int. J. Geo-Inf.* **2021**, *10*, 143. [CrossRef]
2. Guan, X.; Wei, H.; Lu, S.; Dai, Q.; Su, H. Assessment on the urbanization strategy in China: Achievements, challenges and reflections. *Habitat Int.* **2018**, *71*, 97–109. [CrossRef]
3. Fang, C. Basic rules and key paths for high-quality development of the new urbanization in China. *Geogr. Res.* **2019**, *38*, 13–22. [CrossRef]
4. Lu, S.; Huang, Y.; Shi, C.; Yang, X. Exploring the Associations Between Urban Form and Neighborhood Vibrancy: A Case Study of Chengdu, China. *ISPRS Int. J. Geo-Inf.* **2019**, *8*, 165. [CrossRef]

5. Chen, J.; Pellegrini, P.; Wang, H. Comparative Residents' Satisfaction Evaluation for Socially Sustainable Regeneration—The Case of Two High-Density Communities in Suzhou. *Land* **2022**, *11*, 1483. [CrossRef]
6. Yue, W.; Chen, Y.; Thy, P.T.M.; Fan, P.; Liu, Y.; Zhang, W. Identifying urban vitality in metropolitan areas of developing countries from a comparative perspective: Ho Chi Minh City versus Shanghai. *Sustain. Cities Soc.* **2021**, *65*, 102609. [CrossRef]
7. Den Hartog, H. Searching for a new identity in a rapidly transforming urban landscape. *Built Herit.* **2017**, *1*, 41–50. [CrossRef]
8. Zhang, R. Integrating ergonomics data and emotional scale to analyze people's emotional attachment to different landscape features in the Wudaokou Urban Park. *Front. Archit. Res.* **2023**, *12*, 175–187. [CrossRef]
9. Adams, P.C. Place attachment: Advances in Theory, Methods and Applications. *Geogr. Rev.* **2015**, *105*, 129–132. [CrossRef]
10. Attoe, W.; Logan, D. *American Urban Architecture: Catalysts in the Design of Cities*; University of California Press: Berkeley, CA, USA, 1989.
11. Liu, S.; Zhang, L.; Long, Y.; Long, Y.; Xu, M. A new urban vitality analysis and evaluation framework based on human activity modeling using multi-source big data. *ISPRS Int. J. Geo-Inf.* **2020**, *9*, 617. [CrossRef]
12. Jacobs, J. *The Death and Life of Great American Cities*; Vintage: New York, NY, USA, 1961.
13. Lynch, K. *Good City Form*; MIT Press: Cambridge, MA, USA, 1984.
14. Gehl, J. *Cities for People*; Island Press: Washington, DC, USA, 2013.
15. Maas, P.R. Towards a Theory of Urban Vitality. Ph.D. thesis, University of British Columbia, Vancouver, BC, Canada, 1984.
16. Montgomery, J. Making a city: Urbanity, vitality and urban design. *J. Urban Des.* **1998**, *3*, 93–116. [CrossRef]
17. Wu, C.; Ye, X.; Ren, F.; Du, Q. Check-in behaviour and spatio-temporal vibrancy: An exploratory analysis in Shenzhen. *China Cities* **2018**, *77*, 104–116. [CrossRef]
18. Yue, Y.; Zhuang, Y.; Yeh, A.G.; Xie, J.-Y.; Ma, C.-L.; Li, Q.-Q. Measurements of POI-based mixed use and their relationships with neighbourhood vibrancy. *Int. J. Geogr. Inf. Sci.* **2017**, *31*, 658–675. [CrossRef]
19. Chhetri, P.; Stimson, R.J.; Western, J. Modelling the factors of neighbourhood attractiveness reflected in residential location decision choices. *Stud. Reg. Sci.* **2006**, *36*, 393–417. [CrossRef]
20. Huang, B.; Zhou, Y.; Li, Z.; Song, Y.; Cai, J.; Tu, W. Evaluating and characterizing urban vibrancy using spatial big data: Shanghai as a case study. *Environ. Plan. B Urban Anal. City Sci.* **2020**, *47*, 1543–1559. [CrossRef]
21. Tu, W.; Zhu, T.; Xia, J.; Zhou, Y.; Lai, Y.; Jiang, J.; Li, Q. Portraying the spatial dynamics of urban vibrancy using multisource urban big data. *Comput. Environ. Urban Syst.* **2020**, *80*, 101428. [CrossRef]
22. Jin, X.; Long, Y.; Sun, W.; Lu, Y.; Yang, X.; Tang, J. Evaluating cities' vitality and identifying ghost cities in China with emerging geographical data. *Cities* **2017**, *63*, 98–109. [CrossRef]
23. Jacobs-Crisioni, C.; Rietveld, P.; Koomen, E.; Tranos, E. Evaluating the impact of land-use density and mix on spatiotemporal urban activity patterns: An exploratory study using mobile phone data. *Environ. Plan. A* **2014**, *46*, 2769–2785. [CrossRef]
24. Carmona, M. Place value: Place quality and its impact on health, social, economic and environmental outcomes. *J. Urban Des.* **2019**, *24*, 1–48. [CrossRef]
25. Kang, C.; Fan, D.; Jiao, H. Validating activity, time, and space diversity as essential components of urban vitality. *Environ. Plan. B Urban Anal. City Sci.* **2021**, *48*, 1180–1197. [CrossRef]
26. Zhang, R.; Zhuang, W. A Preliminary Study on the Problems and Solutions to Interaction between People and the Built Environment in the Age of Information. *Archit. J.* **2017**, *11*, 96–103.
27. Liu, Y.; Kang, C.; Wang, F. Towards big data-driven human mobility patterns and models. *Geometics Inf. Sci. Wuhan Univ.* **2014**, *39*, 660–666.
28. Candia, J.; González, M.C.; Wang, P.; Schoenharl, T.; Madey, G.; Barabási, A.-L. Uncovering individual and collective human dynamics from mobile phone records. *J. Phys. A Math. Theor.* **2008**, *41*, 224015. [CrossRef]
29. Shi, L.; Chi, G.; Liu, X.; Liu, Y. Human mobility patterns in different communities: A mobile phone data-based social network approach. *Ann. GIS* **2015**, *21*, 15–26. [CrossRef]
30. Niu, X.; Wu, W.; Li, M. Influence of built environment on street vitality and its spatiotemporal characteristics based on LBS positioning data. *Urban Plan. Int.* **2019**, *34*, 28–37. [CrossRef]
31. Kim, Y.-L. Seoul's Wi-Fi hotspots: Wi-Fi access points as an indicator of urban vitality. *Comput. Environ. Urban Syst.* **2018**, *72*, 13–24. [CrossRef]
32. Lv, G.; Zheng, S.; Hu, W. Exploring the relationship between the built environment and block vitality based on multi-source big data: An analysis in Shenzhen, China. *Geomat. Nat. Hazards Risk* **2022**, *13*, 1593–1613. [CrossRef]
33. Wang, W.; Li, S.; Wang, H.; Peng, Z. Spatial Features of Urban Vitality and the Impact of Built Environment on Them Based on Multi-Source Data: A Case Study of Shenzhen. *Trop. Geogr.* **2021**, *41*, 1280–1291. [CrossRef]
34. Ta, N.; Zeng, Y.; Zhu, Q.; Wu, J. Relationship between built environment and urban vitality in Shanghai downtown area based on big data. *Sci. Geogr. Sin* **2020**, *40*, 60–68.
35. Long, Y.; Li, L.; Li, S.; Chen, L.; Pan, Z.; Yao, Y.; Chen, M.; Wang, Y.; Kwon, K.; Quan, J.; et al. Measurment of Street Walking Environment Index for Urban Vitality Centers in Chinese Cities. *South Archit.* **2021**, *1*, 114–120. [CrossRef]
36. Yue, H.; Zhu, X. Exploring the relationship between urban vitality and street centrality based on social network review data in Wuhan, China. *Sustainability* **2019**, *11*, 4356. [CrossRef]
37. Altman, I.; Low, S.M. *Place Attachment*; Springer Science & Business Media: Berlin/Heidelberg, Germany, 2012; Volume 12.
38. Lewicka, M. Place attachment: How far have we come in the last 40 years? *J. Environ. Psychol.* **2011**, *31*, 207–230. [CrossRef]
39. Stokols, D. Toward a science of transdisciplinary action research. *Am. J. Community Psychol.* **2006**, *38*, 63–77. [CrossRef]

40. Scannell, L.; Gifford, R. Defining place attachment: A tripartite organizing framework. *J. Environ. Psychol.* **2010**, *30*, 1–10. [CrossRef]
41. Ekkekakis, P. *The Measurement of Affect, Mood, and Emotion: A Guide for Health-Behavioral Research*; Cambridge University Press: Cambridge, UK, 2013.
42. Williams, D.R.; Roggenbuck, J.W. Measuring place attachment: Some preliminary results. In Proceedings of the NRPA Symposium on Leisure Research, San Antonio, TX, USA, 20–22 October 1989.
43. Lin, G.; Wu, A.; Cai, K. Research on Place Attachment: Concept, Progress and Trend. *Chin. Landsc. Archit.* **2019**, *35*, 63–66. [CrossRef]
44. Zhang, R. Research on Affective-oriented Brutalist Architecture: Two Cases of Campus Libraries of the University of California. *New Archit.* **2021**, *02*, 62–67.
45. Feng, Y.; Wang, K.; Zhang, Y.; Li, X. An Overview of Research on Rural Public Space and Place Attachment: Concepts, Logics, and Associations. *Chin. Landsc. Archit.* **2021**, *37*, 31–36. [CrossRef]
46. Liu, Q.; Wu, Y.; Xiao, Y.; Fu, W.; Zhuo, Z.; van den Bosch, C.C.K.; Huang, Q.; Lan, S. More meaningful, more restorative? Linking local landscape characteristics and place attachment to restorative perceptions of urban park visitors. *Landsc. Urban Plan.* **2020**, *197*, 103763. [CrossRef]
47. Tuan, Y.-F. Space and place: Humanistic perspective. In *Philosophy in Geography*; Springer: Berlin/Heidelberg, Germany, 1979; pp. 387–427.
48. Arnberger, A.; Budruk, M.; Schneider, I.E.; Stanis, S.A.W. Predicting place attachment among walkers in the urban context: The role of dogs, motivations, satisfaction, past experience and setting development. *Urban For. Urban Green.* **2022**, *70*, 127531. [CrossRef]
49. Fried, M. Grieving for a lost home. In *Social Psychiatry*; Routledge: Abingdon, UK, 1970; pp. 335–359.
50. Zhang, R.; Dai, Y.; Sun, Z. A Multi-Dimensional Affective Evaluation Method for Chinese Traditional Village:Take Yangchan Tulou Village in She County, Huangshan City, Anhui Province as an Example. *Archit. J.* **2022**, *S1*, 231–238.
51. Birnbaum, L.; Wilhelm, C.; Chilla, T.; Kröner, S. Place attachment and digitalisation in rural regions. *J. Rural Stud.* **2021**, *87*, 189–198. [CrossRef]
52. Zavadskas, E.K.; Turskis, Z. Multiple criteria decision making (MCDM) methods in economics: An overview. *Technol. Econ. Dev. Econ.* **2011**, *17*, 397–427. [CrossRef]
53. Zavadskas, E.K.; Turskis, Z.; Kildienė, S. State of art surveys of overviews on MCDM/MADM methods. *Technol. Econ. Dev. Econ.* **2014**, *20*, 165–179. [CrossRef]
54. Emrouznejad, A.; Marra, M. The state of the art development of AHP (1979–2017): A literature review with a social network analysis. *Int. J. Prod. Res.* **2017**, *55*, 6653–6675. [CrossRef]
55. Ogrodnik, K. Multi-Criteria Analysis of Design Solutions in Architecture and Engineering: Review of Applications and a Case Study. *Buildings* **2019**, *9*, 244. [CrossRef]
56. Foroozesh, F.; Monavari, S.M.; Salmanmahiny, A.; Robati, M.; Rahimi, R. Assessment of sustainable urban development based on a hybrid decision-making approach: Group fuzzy BWM, AHP, and TOPSIS–GIS. *Sustain. Cities Soc.* **2022**, *76*, 103402. [CrossRef]
57. Shen, L.; Zhang, Y.; Yao, M.; Lan, S. Combination Weighting Integrated with TOPSIS for Landscape Performance Evaluation: A Case Study of Microlandscape from Rural Areas in Southeast China. *Sustainability* **2022**, *14*, 9794. [CrossRef]
58. Hajduk, S.; Jelonek, D. A Decision-Making Approach Based on TOPSIS Method for Ranking Smart Cities in the Context of Urban Energy. *Energies* **2021**, *14*, 2691. [CrossRef]
59. Chen, Y.; Zhu, M.; Lu, J.; Zhou, Q.; Ma, W. Evaluation of ecological city and analysis of obstacle factors under the background of high-quality development: Taking cities in the Yellow River Basin as examples. *Ecol. Indic.* **2020**, *118*, 106771. [CrossRef]
60. Liu, W.; Yang, J.; Gong, Y.; Cheng, Q. An Evaluation of Urban Renewal Based on Inclusive Development Theory: The Case of Wuhan, China. *ISPRS Int. J. Geo-Inf.* **2022**, *11*, 563. [CrossRef]
61. Harputlugil, T. Analytic hierarchy process (AHP) as an assessment approach for architectural design: Case study of architectural design studio. *Archives* **2018**, *6*, 2. [CrossRef]
62. Ribera, F.; Nesticò, A.; Cucco, P.; Maselli, G. A multicriteria approach to identify the Highest and Best Use for historical buildings. *J. Cult. Herit.* **2020**, *41*, 166–177. [CrossRef]
63. Jalilzadehazhari, E.; Vadiee, A.; Johansson, P. Achieving a trade-off construction solution using BIM, an optimization algorithm, and a multi-criteria decision-making method. *Buildings* **2019**, *9*, 81. [CrossRef]
64. Zhu, Y.; Huang, W.; Hu, L. Research on a Commercial Building Space Traffic Flow Design Based on Post-Occupancy Evaluation. *Buildings* **2022**, *12*, 838. [CrossRef]
65. Zhuang, W.; Han, M. Post-Occupancy Evaluation A Review of Methods and State-of-the-Art Techniques. *Time+ Archit.* **2019**, *4*, 46–51.
66. Moghtadernejad, S.; Chouinard, L.E.; Mirza, M.S. Multi-criteria decision-making methods for preliminary design of sustainable facades. *J. Build. Eng.* **2018**, *19*, 181–190. [CrossRef]
67. Hwang, C.-L.; Yoon, K.; Hwang, C.-L.; Yoon, K. Methods for multiple attribute decision making. *Mult. Attrib. Decis. Mak. Methods Appl. A State—Art Surv.* **1981**, 58–191. [CrossRef]
68. Zhao, D.-Y.; Ma, Y.-Y.; Lin, H.-L. Using the Entropy and TOPSIS Models to Evaluate Sustainable Development of Islands: A Case in China. *Sustainability* **2022**, *14*, 3707. [CrossRef]

69. Tang, J.; Zhu, H.L.; Liu, Z.; Jia, F.; Zheng, X.X. Urban Sustainability Evaluation under the Modified TOPSIS Based on Grey Relational Analysis. *Int. J. Environ. Res Public Health* **2019**, *16*, 256. [CrossRef]
70. Liang, X.; Zhang, W.; Chen, L.; Deng, F. Sustainable Urban Development Capacity Measure—A Case Study in Jiangsu Province, China. *Sustainability* **2016**, *8*, 270. [CrossRef]
71. Kilic, H.S.; Yalcin, A.S. Comparison of municipalities considering environmental sustainability via neutrosophic DEMATEL based TOPSIS. *Socio-Econ. Plan. Sci.* **2021**, *75*, 100827. [CrossRef]
72. Chenhong, X.; Guofang, Z. The spatiotemporal evolution pattern of urban resilience in the Yangtze River Delta urban agglomeration based on TOPSIS-PSO-ELM. *Sustain. Cities Soc.* **2022**, *87*, 104223. [CrossRef]
73. Xun, X.; Yuan, Y. Research on the urban resilience evaluation with hybrid multiple attribute TOPSIS method: An example in China. *Nat. Hazards* **2020**, *103*, 557–577. [CrossRef]
74. Liu, D.; Shi, Y. The Influence Mechanism of Urban Spatial Structure on Urban Vitality Based on Geographic Big Data: A Case Study in Downtown Shanghai. *Buildings* **2022**, *12*, 569. [CrossRef]
75. Dong, Y.-H.; Peng, F.-L.; Guo, T.-F. Quantitative assessment method on urban vitality of metro-led underground space based on multi-source data: A case study of Shanghai Inner Ring area. *Tunn. Undergr. Space Technol.* **2021**, *116*, 104108. [CrossRef]
76. Zhang, Y.; Yang, L.; Wang, X. Analysis and Calculating of Comprehensive Urban Vitality Index by Multi-Source Temporal-Spatial Big Data and EW-TOPSIS. In Proceedings of the 2021 IEEE International Conference on Data Science and Computer Application (ICDSCA), Dalian, China, 29–31 October 2021; pp. 196–201.
77. Yang, Y.; Wang, H.; Qin, S.; Li, X.; Zhu, Y.; Wang, Y. Analysis of Urban Vitality in Nanjing Based on a Plot Boundary-Based Neural Network Weighted Regression Model. *ISPRS Int. J. Geo-Inf.* **2022**, *11*, 624. [CrossRef]
78. Šiožinytė, E.; Antuchevičienė, J.; Kutut, V. Upgrading the Old Vernacular Building To Contemporary Norms: Multiple Criteria Approach. *J. Civ. Eng. Manag.* **2014**, *20*, 291–298. [CrossRef]
79. Šiožinytė, E.; Antuchevičienė, J. Solving the Problems of Daylighting and Tradition Continuity in a Reconstructed Vernacular Building. *J. Civ. Eng. Manag.* **2013**, *19*, 873–882. [CrossRef]
80. Lin, K.; He, Y.; Yang, Y.; Xiong, L.; Ralegaonkar, R.V. From Topology Optimization to Complex Digital Architecture: A New Methodology for Architectural Morphology Generation. *Adv. Civ. Eng.* **2021**, *2021*, 6839627. [CrossRef]
81. Zhou, X.; Li, H.; Zhang, H.; Zhang, R.; Li, H. A Study on the Cognition of Urban Spatial Image at Community Scale: A Case Study of Jinghu Community in Zhengzhou City. *Land* **2022**, *11*, 1654. [CrossRef]
82. Fun, B. (a). 2019. Available online: https://zhuanlan.zhihu.com/p/55906615 (accessed on 18 February 2023).
83. Wen, W. (c). 2022. Available online: http://www.cabr.com.cn/s/1333-5997-20606.html (accessed on 18 February 2023).
84. News, P. (e). 2019. Available online: http://n.sinaimg.cn/sinacn20190902s/193/w600h393/20190902/9aa3-ieaiqii0671933.jpg (accessed on 18 February 2023).
85. Xintiandi. (f)(g). 2020. Available online: https://www.xintiandi.com/project/xintiandi-shanghai/ (accessed on 18 February 2023).
86. Hu, Y. (h)(i)(j). 2020. Available online: https://www.gzdaily.cn/site2/pad/content/2020-09/24/content_1383310.html (accessed on 18 February 2023).
87. Li, T. (k). 2015. Available online: http://www.soltklcd.com/zh-CN/AboutUs/ProjectSummary (accessed on 18 February 2023).
88. Carvalho, H.W.d.; Andreoli, S.B.; Lara, D.R.; Patrick, C.J.; Quintana, M.I.; Bressan, R.A.; Melo, M.F.d.; Mari, J.d.J.; Jorge, M.R. Structural validity and reliability of the Positive and Negative Affect Schedule (PANAS): Evidence from a large Brazilian community sample. *Braz. J. Psychiatry* **2013**, *35*, 169–172. [CrossRef] [PubMed]
89. Scannell, L.; Gifford, R. The experienced psychological benefits of place attachment. *J. Environ. Psychol.* **2017**, *51*, 256–269. [CrossRef]
90. Rao, C.; Gao, Y. Evaluation Mechanism Design for the Development Level of Urban-Rural Integration Based on an Improved TOPSIS Method. *Mathematics* **2022**, *10*, 380. [CrossRef]
91. Zhang, X.; Zhang, Q.; Sun, T.; Zou, Y.; Chen, H. Evaluation of urban public transport priority performance based on the improved TOPSIS method: A case study of Wuhan. *Sustain. Cities Soc.* **2018**, *43*, 357–365. [CrossRef]

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.