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Spatial Characteristics and Environmental Perception of Place Attachment in Historical Blocks from the Perspective of PPGIS: A Case Study of Shichahai, Beijing

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Abstract Historical and cultural blocks commonly encounter challenges such as weakened traditional social patterns and declined place attachment. Using Shichahai in Beijing as a case study, this research analyzed 245 valid questionnaires employing the public participation geographic information system (PPGIS) framework, kernel density difference analysis, and multiple regression modeling to investigate the spatial differentiation and environmental influencing mechanisms of place attachment among residents and tourists. The results indicated a significant host-guest social spatial differentiation in place attachment (F=12.67, p<0.001). Residents exhibited identity-driven attachment to their homes, whereas tourists demonstrated functionally oriented attachment related to tourism. Among environmental predictors, only the historical and cultural atmosphere and spatial scale were found to be significant. General environmental factors, such as natural landscapes and social interactions, did not show significant effects. The research reveals that the emotional connection to historical blocks does not follow a linear logic of "supply–perception–attachment". Instead, it is a complex process driven jointly by the cognition of spatial cultural features and daily practices, providing empirical evidence to support the micro-renewal of old cities.

Keywords Shichahai, Historical and cultural block, Place attachment, Host-guest differentiation, Public participation geographic information system (PPGIS)

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With the advancement of urbanization, the homogenization of landscapes in the renovation of old cities results in the diminishing of distinctive urban characteristics, accompanied by a continuous decline in users' sense of spatial belonging. As bearers of local memory, the preservation and revitalization of historical and cultural blocks should transition from solely maintaining their physical appearance to actively addressing the emotional needs of users. Place attachment is defined as the sum of material dependence and emotional connection developed through interactions between individuals and places, serving as a fundamental indicator for assessing the relationship between people and their environments. Specifically, place dependence focuses on functional connection, whereas place identity highlights profound emotion and a sense of self-belonging[1-2]. Previous research has shown that the physical environment[3-4], social factors[5], and behavioral activities[6] significantly influence place attachment. However, owing to the predominance of the recreational perspective, the majority of existing studies have concentrated primarily on pure tourist attractions, while insufficient attention has been directed toward "host-guest shared" historical blocks that serve both residential and tourism functions. In terms of methods, there has been a greater focus on quantitative evaluation of emotions, which has led to a disjunction between emotional information and spatial information. In recent years, some scholars have attempted to materialize local emotions through spatial mapping technologies[7], and the introduction of public participation geographic information systems (PPGIS) has further provided an effective tool for the integrative coupling of emotional quantification and spatial information.

To this end, the study employed PPGIS technology to integrate emotional and spatial information. The Shichahai Historical and Cultural Block in Beijing was selected as a case study, with a focus on three primary research questions: within the context of tourism and spatial reconstruction, what differentiations exist between residents and tourists regarding place attachment among users in Shichahai? Does the explanatory power of environmental variables—commonly considered emotional catalysts in conventional settings—change within the context of historical blocks? How can optimization strategies for micro public spaces be developed based on the actual predictive effectiveness of micro environmental factors?

This study seeks to clarify the primary factors that drive place attachment in historical blocks and to offer planning guidelines for harmonizing the spatial needs of residents and tourists.

1 Research subjects, data sources and research methods

1.1 Research subjects

The Shichahai Historical and Cultural Block in Beijing was selected as the case study site. Located in the northeastern part of Xicheng District, Beijing, Shichahai encompasses three water bodies—Qianhai, Houhai, and Xihai—along with the adjacent streets, alleys, and hutongs, covering a total area of approximately 146.7 hm^2. It represents one of the best-preserved and largest historical areas within the core of Beijing's old city. This district integrates natural landscapes, historical relics, traditional residences, and modern commercial establishments, exemplifying a typical "host-guest shared" urban historical space. Preliminary research shows that users' spatial preferences exhibit regional characteristics, with their behavioral trajectories distributed planarly along streets, alleys, and hutong clusters. Accordingly, the present study categorizes Shichahai into six types based on the consistency of functional attributes and landscape features: landmark nodes (A1-A5), commercial and leisure areas (B1-B2), cultural relic protection courtyards (C1-C5), green spaces and water bodies (D1-D3), hutong residential areas (E1-E3), and waterfront walkways (F1-F2). In total, 20 spatial units were identified (Table 1), which serve as fundamental units for assessing spatial preference and place attachment.

1.2 Data sources and research methods

This study conducted data collection in May 2025, employing a combination of online and offline questionnaire distribution methods. A total of 245 valid questionnaires were obtained, comprising 69 from residents and 176 from tourists, of whom 78 were local tourists and 98 were from other regions. Additionally, 490 spatial

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preference data points were gathered. The survey instruments encompassed measures of visiting behavior, demographic characteristics, and a place attachment and environmental perception scale consisting of 16 items. This scale was adapted from the established items developed by Williams et al. (2003) to suit the context of historical blocks. It included subscales for place dependence (5 items), place identity (5 items), and environmental perception (6 items), all rated using a 5-point Likert scale.

To address statistical bias arising from discrepancies in the total number of resident and tourist samples during spatial visualization analysis, the "spatial unit selection rate (%)" within each group was employed as a relative weight (*Z* value). The coordinates of the geometric center sampling points for 20 spatial units were imported into ArcMap 10.8 and projected into the WGS 1984 Web Mercator coordinate system. An attachment intensity surface was generated using kernel density analysis, followed by spatial subtraction performed via the raster calculator (Diff=Continuous surface of resident selection rate–Continuous surface of tourist selection rate). This process ultimately produced the host-guest attachment difference surface.

2 Results and analysis

2.1 Analysis of sample characteristics and tourism behaviors

Among the 245 valid questionnaires, respondents comprised residents (28.2%), local tourists (31.8%), and non-local tourists (40.0%). The majority of participants were aged between 18 and 35 years (64.9%), and 68.1% held a bachelor's degree or higher. Residents primarily engaged in daily leisure activities (82.3%) and physical fitness (34.2%), demonstrating continuous attachment behaviors linked to their residential areas. In contrast, non-local tourists predominantly participated in tourism (79.1%) and cultural experiences (65.7%), indicating a dispersed attachment behavior centered around landmarks.

2.2 Reliability and validity test

The results of the reliability and validity analysis (Table 2) indicated that the Cronbach's α coefficients for each subscale ranged from 0.854 to 0.881, while the overall scale demonstrated a Cronbach's α of 0.901. The KMO measure was 0.914, and Bartlett's test of sphericity yielded χ^2=1,832.354, df=120, p<0.001. These findings suggest that the data exhibit satisfactory reliability and validity.

2.3 Spatial preferences and distribution characteristics of place attachment

Frequency analysis revealed that residents mainly selected living spaces such as Houhai Park and Liuyin Street, whereas tourists were primarily concentrated in commercial landmarks including Yinding Bridge, Yandai Xiejie, and Prince Gong's Mansion. When categorizing spatial units into six types, tourists exhibited higher selection rates in landmark nodes (70.8%), commercial and leisure areas (55.0%), and cultural relic protection courtyards (52.9%) compared to residents. Conversely, residents showed greater preference for green spaces and water bodies (67.0%), hutong residential areas (52.3%), and waterfront walkways (44.3%) relative to tourists. The χ^2 test assessing spatial selection between residents and tourists indicated a significant differentiation in spatial preferences between the two groups (χ^2=47.82, p<0.001). This pattern aligns with the established transformation of daily living spaces within historical blocks into commercial and recreational spaces. The inconsistency in resource utilization and behavioral trace between residents and tourists frequently results in pronounced spatial differentiation[8].

Following the implementation of the intra-group selection rate leveling treatment, the host-guest place attachment patterns demonstrated significant "spatial convergence" (Figs.1−2). Notably, regions exhibiting high attachment overlapped extensively along the central core waterfront axis. Spatial analysis of the difference surface (Fig.3) revealed that areas with a resident emotional advantage (positive Diff values) were mainly concentrated in Prince Gong's Mansion (Diff=6.35), the Houhai South Bank Walkway (Diff=3.07), and the Jinsi Hutong area (Diff=2.72). Areas with a tourist emotional advantage (negative Diff values) were located at Wanghai Tower (Diff=−1.80) and Bar Street (Diff=−0.78). The Yinding Bridge (Diff=0.46) and Yandai Xiejie (Diff=0.59) represented zones where resident and tourist emotions were closely coupled. Here, Diff=Continuous surface of resident selection rate–Continuous surface of tourist selection rate.

2.4 One–way analysis of variance on the difference in place attachment levels between residents and tourists

A one-way analysis of variance (Table 3) revealed significant differences in the overall level of place attachment among the various groups (F=12.67, p<0.001). Residents exhibited the highest total score (4.14±0.59), characterized by a home-based attachment characteristics of identity (4.32±0.66) > dependence (3.97±0.77). Non-local tourists demonstrated the lowest total score (3.20±0.70), characterized by tourism attachment characteristics of dependence (3.38±0.83)>identity (3.02±0.86). Local tourists scored intermediate values (3.61±0.80). Quantitative analysis suggests that these differences arise from fundamental variations in spatial practice density and the manner in which multiple subjects ascribe meaning to place. Specifically, residents tend to develop an authentic identity grounded in kinship and neighborhood ties, whereas tourists' emotional connections are more reliant on landscape offerings and commercial experiences[9-10].

2.5 Analysis of influencing factors of place attachment

2.5.1 Group differences in spatial feature perception. The regression model presented in this section

Table 1 Spatial unit division and coding of Shichahai

Type of spatial unit	Name and code of spatial unit
Landmark nodes	A1 Yinding Bridge, A2 Yandai Xiejie, A3 Prince Gong's Mansion, A4 Jinding Bridge, A5 Wanghai Tower
Commercial and leisure areas	B1 Bar Street, B2 Lotus Market
Cultural relic protection courtyards	C1 Guo Moruo's Former Residence, C2 Former Residence of Soong Ching Ling, C3 Prince Chun's Mansion, C4 Huoshen Temple, C5 Guanghua Temple
Green spaces and water bodies	D1 Houhai Park, D2 Xihai Wetland, D3 Huitong Temple
Hutong residential areas	E1 Jinsi Hutong Area, E2 Ya'er Hutong, E3 Liuyin Street
Waterfront walkways	F1 Qianhai East Bank Walkway, F2 Houhai South Bank Walkway

Table 2 Reliability and validity of the place attachment and environmental perception scale

Latent variable dimension	Number of items	Cronbach's α	KMO measure	Bartlett's test of sphericity (χ^2)	Degree of freedom (df)	Significance (p)
Place dependence	5	0.854				
Place identity	5	0.881	0.914	1,832.354	120	< 0.001
Environmental perception	6	0.858				
Total scale	16	0.901				

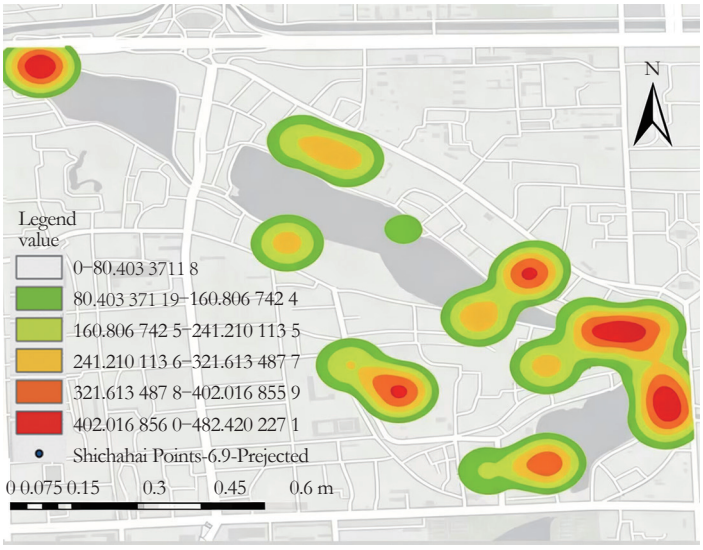

Fig.1 Spatial distribution of residents' place attachment intensity

Fig.2 Spatial distribution of tourists' place attachment intensity

Fig.3 Spatial distribution of attachment differences between residents and tourists

was designed to evaluate the predictive capacity of environmental perception factors on place attachment. Since the differences in host-guest identities were previously examined through analysis of variance in Section 2.4, these variables were excluded from the regression model. Descriptive statistical analysis of the environmental perception items revealed a notable imbalance in respondents' perceptions of Shichahai's environmental characteristics. Across all groups, the highest scores were attributed to the historical and cultural atmosphere (residents: 4.47; local tourists: 4.32; non-local tourists: 4.15), followed by spatial scale (mean scores of 4.12, 4.05, and 3.98, respectively; overall mean approximately 4.05), indicating a strong consensus regarding the authenticity of the old city's appearance. Median scores predominated for social interaction and accessibility. Seating facilities received the lowest perception scores across all groups (3.38–3.52), reflecting the real historical constraints on the provision of micro-recreational facilities.

2.5.2 Regression analysis of the environmental influencing factors of place attachment. A multiple linear regression analysis was conducted with the total score of place attachment as the dependent variable (Table 4). The model demonstrated a satisfactory overall fit (F=13.463, p<0.001, adjusted R^2=0.235). The findings indicated that both historical and cultural atmosphere (β=0.153, p=0.034) and spatial scale (β=0.149, p=0.044) were significant positive predictors of place attachment.

Environmental variables commonly identified as significant in conventional urban public space research, such as natural landscape, social interaction, accessibility, and seating facilities, did not achieve statistical significance in this model (p>0.05). The consistent lack of explanatory power of these factors reflects the distinctive spatial attributes and functional construction of host-guest shared historical blocks. This finding suggests that the emotional connection mechanisms within historical and cultural blocks differ from the typical linear pathway observed in general urban spaces, which follows the sequence of "environmental supply, feature perception, and place attachment". Instead, the process is complex and jointly driven by deep cultural capital, the perception of feature authenticity, and micro-level life practices. Research in heritage tourism further corroborates that the perception of the authenticity of historical features not only constitutes the source of a block's uniqueness but also serves as the primary impetus for users to develop historical resonance and a profound local identity[11-12].

The failure of this factor is also evident

in the host-guest emotional coupling areas, such as Yinding Bridge and Yandai Xiejie, as discussed in Section 2.3. From the perspective of spatial mechanism analysis, these areas exhibit dual spatial functions, serving both as landmark tourism locations and daily commuting routes. Although various groups frequently coexist physically at these nodes, the highly mobile commercial tourism format has resulted in fragmented spatial stay behaviors. This fragmentation impedes the development of in-depth social interactions, thereby hindering the transformation of "social interaction" into place-based emotional attachment. This phenomenon aligns closely with empirical findings from similar historical blocks in Harbin and Beijing[13-15], collectively confirming the replacement and reconstruction effects of highly mobile tourism commercial spaces on traditional local neighborhood interactions and settled emotional attachments[16].

3 Public space optimization strategy based on place attachment

3.1 Continuing the texture of historical features and the scale of authenticity

Given the strong predictive power of historical and cultural atmosphere (β=0.153) and spatial scale (β=0.149) as shown in Table 4, spatial renewal efforts should prioritize the preservation of the authenticity of high-attachment hutong residential areas. It is essential to strictly regulate the width-to-height ratio and enclosure characteristics of traditional streets and alleys. Renovation materials and colors must adhere to traditional historical styles to reinforce the material basis of place identity. The renewal of old urban areas should avoid indiscriminate development of large-scale square landscapes; instead, it should implement acupuncture-style small-scale interventions that maintain the original micro-scale structure of the hutongs and streets[17].

3.2 Building an adjustment and buffer network for the spatial order of residents and tourists

The social interaction factor did not achieve statistical significance in the multiple regression analysis (β=0.095, p=0.221), suggesting that in highly mobile host-guest shared environments such as Shichahai, the pathway of "enhancing attachment through interaction frequency" in general public spaces is not supported. The commercialization of tourism has structurally constrained the daily social networks of local residents. Consequently, spatial strategies should shift from "promoting interaction between residents and tourists" to "reorganizing the spatial order of residents and tourists". A physical and psychological buffer zone should be established between the commercial and tourism axis along the lake and the hutong residential area. Within the core residential area of the hutong, stock spaces that have undergone functional transformation should be utilized to provide residents with low-disturbance places for daily interaction, thereby protecting the rights and interests of the settled community's living environment[18].

3.3 Promoting localized restoration and style integration of public facilities

The satisfaction rate for seating facilities was the lowest among all types (3.38–3.52), and the regression analysis indicated no significant effect (β=0.067, p=0.362). This discrepancy between "low satisfaction scores and the lack of statistical significance" highlights the limitations of standardized facility provision within the historical context of the old city. Optimization efforts should move beyond the mere assemblage of general benches and instead focus on the integrated incorporation of rest facilities with the historical landscape features. Rest functions should be combined with existing elements such as steps, low walls, and tree pits within the urban block. This approach would transform facility provision from general functional arrangements into place elements that are deeply embedded in the historical environment and aligned with daily behavioral trace, thereby addressing users' substantive concerns related to the core demands of historical and cultural ambiance as well as spatial scale.

4 Conclusions

This study examined the spatial differentiation and environmental influence mechanism of place attachment among users of the Shichahai Historical and Cultural Block in Beijing. The principal findings are as follows:

(1) A significant host-guest social spatial differentiation in place attachment was observed (F=12.67, p<0.001). Residents demonstrated a "continuous attachment to their homes", primarily characterized by emotional identity, whereas non-local tourists exhibited a more "dispersed tourism attachment", predominantly grounded in functional dependence. Local tourists occupied an intermediate position between these two groups. The primary factors driving this differentiation were the depth of spatial practice and the orientation toward daily needs.

(2) The emotional triggering mechanisms associated with environmental factors exhibit distinct characteristics. Among these, the historical and cultural atmosphere and micro-spatial scale emerge as the only significant

Table 3 One–way analysis of variance on the difference in place attachment levels between residents and tourists

Attachment dimension	Resident group (n=69)	Local tourist group (n=78)	Nonlocal tourist group (n=98)	F	p
Place dependence (M±SD)	3.97±0.77	3.60±0.95	3.38±0.83	–	–
Place identity (M±SD)	4.32±0.66	3.63±0.83	3.02±0.86	–	–
Overall place attachment	4.14±0.59	3.61±0.80	3.20±0.70	12.67	<0.001

Table 4 Multiple linear regression of influencing factors of place attachment

Independent variable	Standardized path coefficient (β)	t	p	Overall fitting indicator of the model
Historical and cultural atmosphere	0.153	2.127	0.034	Adjusted R^2=0.235
Spatial scale	0.149	2.023	0.044	F=13.463
Natural landscape	0.098	–	0.195	Overall model p<0.001
Social interaction	0.095	–	0.221	
Accessibility	0.093	–	0.208	
Seating facilities	0.067	–	0.362	

environmental predictors, forming the fundamental basis for the emotional attachment to a place. The lack of explanatory power of conventional factor, such as natural, social, and standardized service facilities, indicates a disconnection between the general spatial provisions and the profound local emotional connections within historical spaces shared by both residents and tourists. These findings offer empirical support for micro-urban renewal initiatives and the cultivation of community resilience in comparable historical blocks.

(3) A precise renewal strategy for old cities, grounded in the effectiveness of empirical factors and spatial differentiation patterns, is proposed. The optimization of micro-spaces within historical blocks should not adhere to the conventional high-supply model typical of general public spaces. Instead, it should adopt a dual-track approach that "reinforces cultural authenticity" while "reorganizing the spatial order between residents and tourists". By focusing on key driving variables and preserving low-scale forms alongside localized micro-facilities, the material basis of place identity is strengthened, facilitating the harmonious coexistence of emotional experiences between residents and tourists within shared spaces.

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