

Article

Influence of Spatial Configuration on the Cultural Cognition of Urban Heritage: The Case of Shanghai

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Abstract

Urban heritage revitalization relies on public cultural cognition, yet the psychological impact of spatial morphology remains under-quantified. This study integrates space syntax with survey data to evaluate the relationship between five spatial metrics and six cultural dimensions, including authenticity, integrity, vitality, involvement, diversity, and identity, across three heritage cases. Correlation and clustering analyses reveal that spatial configuration dictates distinct cultural cognitions rather than universally positive effects. This study identified three spatial-cultural typologies: an authentic traditional revitalized area, where high visual entropy preserves authenticity but limits involvement; a high-quality hub, which utilizes high integration and connectivity to holistically enhance all cultural cognitions; and a functional and vital art area, where spatial control for modern vitality is maximized at the expense of historical identity. These findings demonstrate that morphological variables serve as active, quantifiable predictors of cultural impact, moving the discourse of space and culture from a metaphor to an empirical framework. This study provides actionable design strategies for balancing functional efficiency with historical preservation in sustainable urban (re)development.

Keywords: urban heritage; cultural cognition; spatial configuration; space syntax; Shanghai

1. Introduction

Culture has been embedded in SDG 11 since UNESCO's 2015 agenda, not as a fourth pillar but as a core element that fuses economic, social, and environmental objectives into human-centered development [1,2]. People interpret and reshape space through lived experience. Thus, policies that claim to be “inclusive” should account for how cultural meaning is understood and reproduced [3].

Urban heritage is the clearest example of this recursive loop: it is simultaneously a physical artifact and a cultural carrier whose meaning is continuously renegotiated during revitalization [4,5]. Urban heritage refers to the built environment and its associated intangible cultural expressions, formed and bequeathed through historical development, which embody the collective memory, esthetic values, social functions, and cultural identity of a specific community [6]. It encompasses individual monuments or buildings and emphasizes the holistic integrity of the urban fabric or landscape, comprising building



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clusters, street patterns, open spaces, infrastructure, and natural topography. Culture endows heritage with meaning and value, while heritage endows culture with a physical carrier and a space for representation. An object or place becomes the heritage of a community only when it is imbued with cultural value and significance by that group. Based on the characteristics of and relationship between culture and heritage revitalization, revitalized patterns can be divided into three types: interpretive revitalization, integrative revitalization, and instrumental revitalization [7].

However, different groups understand the cues implied in heritage in different ways. Dan Kahan argued that individuals do not merely absorb information; they actively filter it through the lens of their pre-existing cultural worldviews to protect their identity and group affiliations [8,9]. This means the same material cue could be interpreted in radically different or even oppositional ways by different groups. For heritage revitalization, the necessary feedback must not only determine if significance is understood but, more critically, it must diagnose how it is cognized and refracted through these powerful cultural filters to truly judge whether revitalization efforts foster shared inheritance or inadvertently deepen cultural divides.

Shanghai has been a multicultural location since it opened to Western countries in 1843. Designers around the world have participated in its functional development, and Shanghai is the blended result. Studying Shanghai's diversity can improve our understanding of culture. Tianzifang, Columbia Circle, and the Start Museum are typical heritage sites in Shanghai; they represent different phases of its rich local culture, but they have different results owing to their design strategies. Thus, they are suitable for exploring the effects of spatial configuration on cultural cognition.

This study aims to understand the interaction between spatial configurations and cultural cognition after urban heritage revitalization. Following this introduction, the study is divided into three parts regarding the spatial configuration and cultural cognition of urban heritage: (1) The first part describes the factors and dimensions included in these components. (2) The second part describes the characteristics of each case. (3) The third part describes the relationship between the components in each case.

2. Literature Review

2.1. *Reframing the Cultural Cognition of Urban Heritage*

The concept of cultural cognition within urban heritage has been broadly defined, encompassing a range of mental activities from sensory perception to memory. However, to build a more robust theoretical foundation, in this study we reframe the cultural cognition of urban heritage within the framework of environmental psychology [10]. It can be regarded as a dynamic person–environment transaction in which individuals cognize, interpret, and derive cultural meaning from the physical fabric of heritage sites [11]. This transactional perspective allows us to construct a multi-layered framework that clarifies how spatial configurations carry cultural significance.

This framework integrates three core theoretical pillars. At the foundational level, Gibson's ecological approach to visual cognition provides a perceptual basis [11]. For Gibson, the setting is not a collection of neutral stimuli but a composition of affordances with actionable possibilities and meanings. The physical setting can directly influence the perceiver. The material cues of heritage thus directly afford connections to the past and possibilities for engagement.

Building upon this cognized layer, Kaplan's Information Processing Model explains the cognitive dimension [12]. Kaplan argues that humans have an innate need to make sense of and feel involved in their settings. Preferred and meaningful settings offer coherence

and legibility as well as complexity and mystery. This explains why some heritage settings successfully engage visitors while others fail.

Finally, the cumulative effect of these perceptual and cognitive interactions leads to the affective outcomes described in broader environmental psychology and place attachment theories. Repeated and meaningful transactions with a place foster a deep psychological connection, shaping one's sense of self and community [13].

Thus, six cultural cognition dimensions were proposed, representing distinct, inter-related facets of this comprehensive person–environment transaction. This allowed us to move from objective physical properties to subjective psychological outcomes.

2.2. *A Multi-Layered Framework for Cultural Cognition in Urban Heritage*

Based on this theoretical grounding, the six dimensions are structured into a conceptual hierarchy that explains their relationships and justifies their inclusion.

2.2.1. Perceptual Foundation of the Heritage's Culture

This layer concerns the objective, material qualities of a heritage site that provide the fundamental affordances for cultural meaning from a Gibsonian perspective.

Cultural Authenticity: Authenticity is the primary affordance that provides a reliable connection to the past, acting as the bedrock for the cognitive experience [11]. However, this concept is not absolute: while historically rooted in the material substance of heritage, it is fundamentally a perceived quality, as our relationship with the past is always mediated by present-day values [14,15]. This complex understanding is reflected in contemporary heritage discourse, such as the UNESCO Recommendation on the Historic Urban Landscape, which expands authenticity beyond a physical fabric to include the continuity of social functions, cultural practices, and the spirit of place. Therefore, authenticity provides not a simple historical record but a credible ground truth, making the heritage environment believable and allowing for meaningful engagement with its other cultural dimensions [14].

Cultural Integrity: Integrity aligns with Kaplan's concept of coherence and legibility. It refers to the wholeness and intactness of the heritage fabric and its context [12]. A high degree of integrity makes a heritage site cognitively manageable, allowing individuals to easily make sense of its structure and narrative, thus forming a coherent mental model of the place.

2.2.2. Dynamic Human–Environment Interaction

This layer focuses on how individuals cognitively process and behaviorally engage with the environment, drawing from Kaplan's model of environmental preference.

Cultural Diversity: Resonating with Kaplan's dimension of complexity, cultural diversity refers to the richness and variety of elements, narratives, and expressions within a heritage site. This complexity provides the necessary informational stimulation to keep individuals engaged, preventing monotony and fostering a deeper, more nuanced understanding of the place's culture.

Vitality: Vitality is the visible manifestation of a successful, thriving person–environment transaction. It reflects the degree to which a space affords and encourages social life and activity. The presence of people and events signals a living heritage, enhancing its attractiveness and reinforcing its contemporary cultural relevance [16].

Cultural Involvement: This dimension directly reflects the behavioral component of the transaction and is linked to Kaplan's concept of involvement and mystery. It measures the extent to which the heritage environment encourages and facilitates active participation through exploration, rituals, or events. This active engagement transforms the individual from a passive observer to an active participant in the cultural life of the place.

2.2.3. Culminating Affective Outcome

This final layer represents the profound psychological connection that emerges from successful perception and interaction.

Cultural Identity: As the apex of the cultural cognition process, cultural identity is a form of place attachment [17]. It is the deep, spiritual, and emotional bond that forms when the cognized meanings of a heritage site resonate with an individual's sense of self, history, and community. It is the ultimate confirmation that the site's cultural significance has not only been understood but internalized.

By structuring the six dimensions within this environmental psychology framework, we establish their conceptual relationships and provide a clear epistemological logic for their selection, moving systematically from what the environment offers to how people interact with it and the ultimate psychological impact.

2.3. Spatial Configuration

Spatial configuration is a metric that describes the associations between two spaces. Hart and Moore [18] regarded spatial configuration as the final stage in the formation of spatial cognition, providing the necessary spatial information and reflecting an individual's spatial cognition. Hillier and Hanson [19] explored the science-based, human-focused approach of space syntax, which indicates configurational relationships between space and its relevant properties. In space syntax, space can be viewed as "a collection of visible real surfaces in space" [20], and its configuration is an important factor that can influence user movement [21–23].

Recent research on the spatial configuration of heritage has focused predominantly on changes to the spatial configuration of heritage and the reasons for these alterations. It has also explored the impact of these alterations on people's lives, memories, and spatial vitality through behavioral methods, such as cognitive maps and gate-count observations [24]. However, limited attention has been paid to the expression of cultural properties and the impact of expressed results on human cognition. Current research in Western countries differs from that in Eastern countries. In the West, discourse on planning has remained largely macroscopic, revolving around the allocation of authoritative voices and the governance of entire urban systems, whereas in Asia, research has concentrated on spatial practices at the finer scale of streets, districts, or single buildings [25,26]. Asian cases span gardens, rural settlements, and historic (religious) structures because their spatial patterns and analytical methods differ from those in Western countries. Compared with their Western counterparts, Asian districts possess sharply defined edges and have evolved over much longer periods; as a result, features from successive eras persist in the present, producing intricate spatial compositions [27,28].

Previous studies have proposed applied factors, such as integration, connectivity, and control, and combining these spatial configuration factors may improve our understanding of their relationships with cultural cognition. These relationships must be studied further to support future heritage conservation.

Following the literature review, a multidisciplinary framework was developed to analyze how people can better understand the culture of heritage through spatial configuration (Figure 1). The cultural cognition dimensions include cultural authenticity, cultural integrity, cultural vitality, cultural involvement, cultural diversity, and cultural identity, while the spatial configuration indicators include global integration, local integration, connectivity, control, and visual entropy. Considering the properties of heritage sites, the spatial configuration in this study involves the configuration of public heritage spaces.

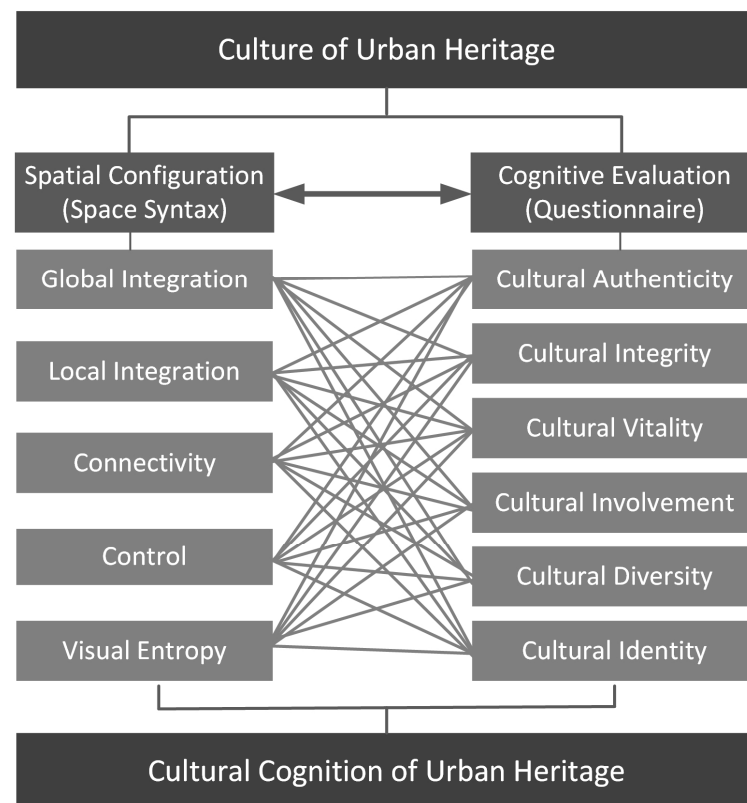


Figure 1. Framework of cultural cognition of urban heritage.

3. Methodology

This study aims to determine the influence of spatial configuration on cultural cognition after heritage revitalization by (1) utilizing space syntax to analyze the spatial configuration of the selected case; (2) exploring the cultural cognition of people in the selected case through questionnaires; and (3) analyzing the relationship between spatial configuration and the cultural cognition of heritage site revitalization with Spearman correlation analyses.

3.1. Study Area

Tianzifang, Columbia Circle, and the Start Museum are typical cases of the three revitalized patterns considered in this study (Figure 2). Tianzifang is located in the Huangpu District and was built in the 1920s. It is a residential area that was revitalized as a living and commercial area. It is typical of interpretive revitalization, and its culture can be divided into three phases: (1) From the 1920s to 1960s, it was a residential area including mansions, lanes, and alleys. (2) From the 1960s to 1997, factories were constructed, and the population increased. Its spatial structures thus changed. (3) After 1998, bottom-up revitalization emerged. Most of its collective memory has been preserved.

Columbia Circle is located at the center of Changning District in Shanghai; it is typical of integrative revitalization. It was built in 1924 by Asia Realty Co. and has undergone three phases: (1) From the 1930s to the 1950s, it was a recreational place for American immigrants. (2) From 1951 to 2014, it was occupied by the Shanghai Institute of Biological Products and utilized for research and work. (3) After 2015, the administration appointed Vanke and Rem Koolhaas of OMA to complete its revitalization, which achieved quality results.



Figure 2. Location of the three cases (Source: Baidu Map).

The Start Museum is located in Xuhui District. It was revitalized from Nanpu Railway Station into an artistic place. It underwent three phases: (1) From 1907 to 1958, it initially served as the Rihui Port but was then renamed Nanpu Railway Station. (2) From 1959 to 2009, the station underwent internal expansion and continued operations until 2009. (3) After the revitalization process that began in 2014, it has been open since 2022. The project is typical of instrumental revitalization because its original building structures, surrounding railway tracks, and station were preserved, while its interior space and function were completely reconstructed.

Figure 3 displays the current spatial configurations of the three cases. The green, yellow, and pink parts indicate buildings in the first, second, and third phases, respectively. Considering the spatial characteristics and different cultural phases, six gates were selected for data collection and analysis.



Figure 3. Layouts of the three cases.

3.2. Data Collection

3.2.1. Space Syntax

In this study, the VGA model of space syntax was applied to analyze the spatial configuration of Columbia Circle using Depthmap Beta 1.0 software (a spatial analysis software originally developed by Alasdair Turner at the Space Syntax Group, UCL). VGA can be used to study the control and influence of localized spatial units in integral systems and explore their social logic [29]. Thus, it is suitable for studying a heritage site on the mesoscopic scale with clear borders but not a complex layout.

The workflow proceeds as follows: (1) identify the research scope and core nodes; (2) select suitable models; (3) construct the spatial network's structural relationships based on topological principles and calculate the urban service radius; (4) generate morphological variables to explore the relationship between a heritage space and its social functions.

In accordance with the scale and areas of the case, the grid properties were set to 10 (grid property = 10 corresponds to 1 m spacing) and the radii were set to n (for global integration) and 3 (for local integration). To avoid border effects, in this study the surrounding entrances and adjacent traffic roads of the case were set as boundaries (Table 1).

Table 1. Technical parameters of space syntax.

Technical Parameters	Parameter Setting
Model	VGA
Software	Depthmap Beta 1.0 software
Grid properties	10
Radius	n (for global integration) and 3 (for local integration) (1) Tianzifang. North: Central Jianguo Road; East: Yuanshui Mansion; South: Taikang Road; West: Qunxian Mansion
Boundaries	(2) Columbia Circle. North: middle of Ecological Mansion and Lu Li Mansion; East: Anxi Road, west of Panyu Road; South: No. 222 Road, Da'an Apartment and Taizi Apartment (3) The Start Museum. North: Ruining Road; East: Grassland; South: riverside of Huangpu River; West: Skateboarding Park

Global integration, local integration, connectivity, control, and visual entropy were applied in this analysis. Global integration is a measure of general syntactic accessibility and is used to reflect the centrality of the integral spatial system [19,30]. The more integrated a space, the more accessible and central it is and the easier it is for people to gather there.

The formula for global integration (GI) is as follows (Ostwald, 2011 [30]):

$$GI = \frac{n - 1}{MVD}$$

where n is the total number of visible nodes in the graph, and MVD (mean visual depth) is the average of the shortest visual distances from a particular node to all other nodes [30].

Local integration (LI) refers to integration values at radius 3 (root plus 2 topological steps from the root), representing a localized picture of integration. LI can reflect the cultural representation of local heritage spaces. A high value tends to be a warm color and demonstrates higher visibility in a space.

The connectivity of a space is the number of surrounding spaces that are directly connected to it [30–32]. This variable indicates the accessibility of spatial properties to the heritage's culture [33,34]. The formula for connectivity is as follows [30,32]:

$$CE_i = k$$

where k is the number of other nodes directly visible from a given node. Warm colors indicate high connectivity, and many local spaces can connect with spaces with high connectivity. Conversely, cold colors indicate low connectivity with other surrounding spaces.

Control indicates the interactive effects of a certain space with its surroundings. A high value of control indicates a close connection and the interaction between this space and its surroundings. The formula for control (CO) is as follows:

$$CO = \sum_{k=1}^j \frac{1}{CE_k}$$

Warm colors indicate the strong influence of a space on its surroundings, while cold colors indicate a weak influence.

Visual entropy measures the distribution of spatial locations in terms of their depths [35]. It indicates the order of a space. The lower its value, the more symmetric and dynamic the space. The formula for visual entropy (VE) is as follows [36,37]:

$$VE = \sum_{d_{min}}^{d_{max}} -p_d \log_2 P_d$$

where d_{max} represents the maximum depth from vertex v , and P_d represents the frequency of point depth d from the vertex. Warm colors indicate high values and visual disorder, whereas cold colors indicate the opposite.

3.2.2. Questionnaire

The public questionnaire consisted of four parts, namely, the purpose of this study, cultural cognition dimension scoring, usage habitats, and respondent profile. Twenty-four questions based on the framework mentioned above were included to evaluate cultural cognition of heritage. Before the public survey, a pilot study was conducted, which provided feedback and amendments to ensure the applicability of the evaluated items. A five-point scoring scale (1 = strongly disagree; 5 = strongly agree) was used to score the degree of cognition. The collection period ranged from 29 March 2025 to 18 May 2026. In total, 655 questionnaires were collected on-site, 652 of which were valid after the test. To capture in situ cognition and eliminate selection bias, data were collected exclusively using on-site systematic random sampling. A fixed sampling interval (every 5th adult) was applied along predetermined walking routes that covered Tianzifang, Columbia Circle, the Start Museum, and their adjacent residential blocks. The starting point was randomly chosen for each session. This study aims to capture the diversity of users' cognitions. The procedure was repeated on both weekdays and weekends, allowing us to include various backgrounds and ages.

Most respondents were between 19 and 65 years old and had different educational backgrounds. Most respondents had lived in Shanghai for 3–5 years or more than 10 years. Their presence in the study areas ranged from 1 to 3 times each week. These data demonstrate that the respondents had basic feelings toward this study area.

3.3. Data Analysis

Given the cross-sectional design and limited sample size of this study, an exploratory comparative case study approach was applied rather than pursuing causal inference. The analysis was conducted using Spearman correlations, and its primary focus was to identify and describe the relationships and patterns between spatial attributes and cognized dimensions, thereby generating hypotheses and providing direction for future confirmatory studies.

The analysis was performed in three steps. First, the spatial configuration data were normalized, as the floor plans of the three cases were at different scales. Second, a Spearman

correlation coefficient analysis was performed for the three cases and the integral analysis. The dimensions of cultural cognition were set as the dependent variable, whereas the global integration, local integration, connectivity, control, and visual entropy of the selected gates were set as the independent variables. Second, a K-means clustering analysis was conducted to divide the selected gates into different revitalized patterns. All analyses were performed with SPSS version 26 software.

4. Results

4.1. Tianzifang

The spatial configuration results of Tianzifang are shown in Figure 4. TZ4 displays the highest local integration and connectivity. This indicates that it is the most central and accessible node within Tianzifang's internal network, functioning as a core hub for pedestrian movements.

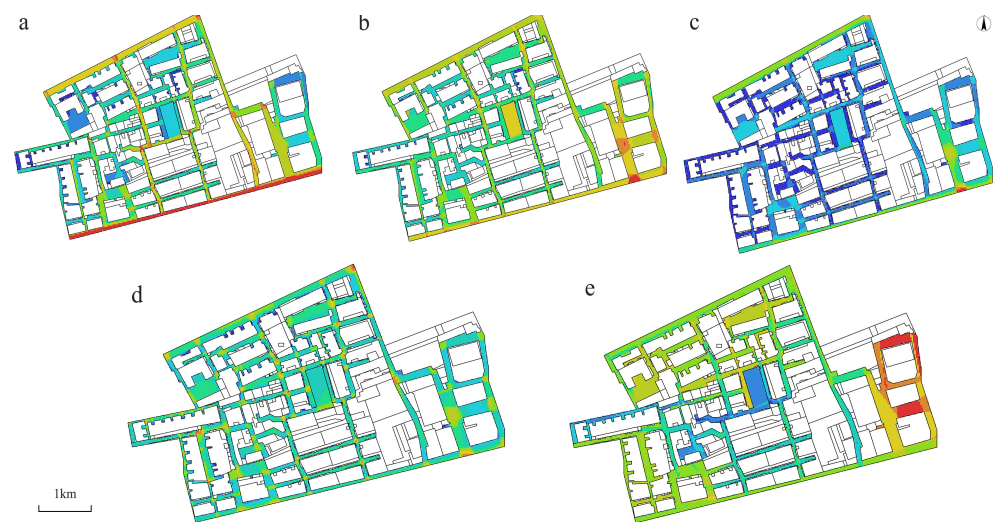


Figure 4. Spatial analysis of Tianzifang with space syntax. (a) Global integration of Tianzifang; (b) Local integration of Tianzifang; (c) Connectivity of Tianzifang; (d) Control of Tianzifang; (e) Visual entropy of Tianzifang.

TZ6 possesses the highest visual entropy and control. This suggests a location with rich visibility, likely an intersection of multiple alleys with dense commercial signage. Its high control value implies that it lies on the shortest path for significant pedestrian movement, making TZ6 a strategically important control point that is also visually complex. TZ3, as an entry point from the outside, has the highest global integration, suggesting superior accessibility.

All observed gates scored high on cultural authenticity but varied significantly in vitality, involvement, and identity (Figure 5).

TZ3 and TZ4 registered the highest scores for vitality and involvement. Specifically, TZ3 excelled in cultural integrity and vitality, while TZ4 led in involvement. As these points are relatively open small plazas at the intersections of main alleyways, they naturally become gathering points for pedestrian flow and activity, which significantly enhances their cognized vitality and participatory quality.

TZ6 scored highest in cultural authenticity but lowest in cultural identity. This paradox arises because it retains the most original, unaltered character. While the public acknowledges its authenticity, this state creates a sense of distance, hindering emotional resonance and identity. It functions more like a museum than a community space.

TZ1, located at the main entrance, achieved the highest score for cultural identity but the lowest for involvement. This is because individuals can strongly establish their identities; for example, I have arrived at Tianzifang but cannot yet deeply engage with the site's activities.



Figure 5. Cultural cognition of Tianzifang.

The correlation analysis revealed that visual entropy has a significant positive correlation with cultural vitality but a significant negative correlation with cultural identity. This suggests that visual richness is interpreted as vitality, yet excessive visual complexity can undermine the public's overall cognitive grasp of the place and its sense of emotional belonging. Local integration showed a positive correlation with cultural involvement, as the well-connected internal alleys encourage lingering, interaction, and consumption. Finally, connectivity was positively correlated with cultural diversity, as gates with more direct connections expose individuals to a wider variety of shops, galleries, and landscapes, enhancing their cultural cognition (Table 2).

Table 2. Spearman correlation analysis of Tianzifang.

	Cultural Authenticity	Cultural Integrity	Cultural Vitality	Cultural Involvement	Cultural Diversity	Cultural Identity
Global Integration	−0.771	0.943 **	0.600	−0.543	−0.257	−0.371
Local Integration	0.771	−0.600	−0.257	1.000 **	0.257	0.143
Connectivity	0.086	−0.086	−0.600	0.029	0.829 *	0.543
Control	0.771	−0.771	−0.029	0.257	0.029	−0.257
Visual Entropy	−0.029	0.143	0.886 *	−0.086	−0.657	−0.943 **

* $p < 0.05$, ** $p < 0.01$, $N = 6$. This correlation is for descriptive purposes only, illustrating the association trends among internal variables in this case, and does not support statistical inference.

4.2. Columbia Circle

The spatial configuration results for Columbia Circle are shown in Figure 6. CC1 displays the highest values for global integration, local integration, connectivity, control, and visual entropy, establishing it as the most dominant spatial location. It is the center of the entire site, where the most open, accessible, and visually permeable point connects the greatest number of surrounding locations. Conversely, CC5 registers the lowest values across all metrics. The data for the remaining gates clearly demonstrate a declining pattern from the core to the periphery.

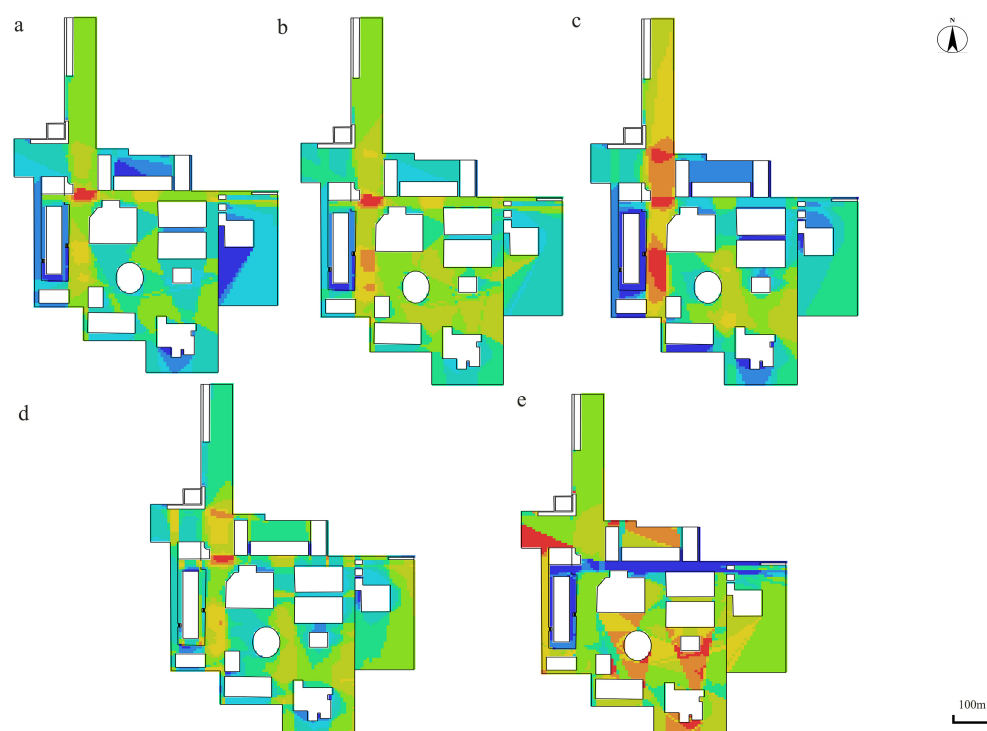


Figure 6. Spatial analysis of Columbia Circle with space syntax. (a) Global integration of Columbia Circle; (b) Local integration of Columbia Circle; (c) Connectivity of Columbia Circle; (d) Control of Columbia Circle; (e) Visual entropy of Columbia Circle.

In terms of cultural cognition, CC1 achieved the highest scores for vitality, involvement, and diversity, underscoring the significance of its central location. CC5 scored the lowest across all dimensions because it is situated at the rear of the Navy Club and is an independent space. Its revitalization preserved most of its historical features, such as mosaic tiles, swimming lanes, and railings, resulting in a high authenticity score. However, due to its poor spatial accessibility, its cognized vitality and involvement are significantly diminished (Figure 7).

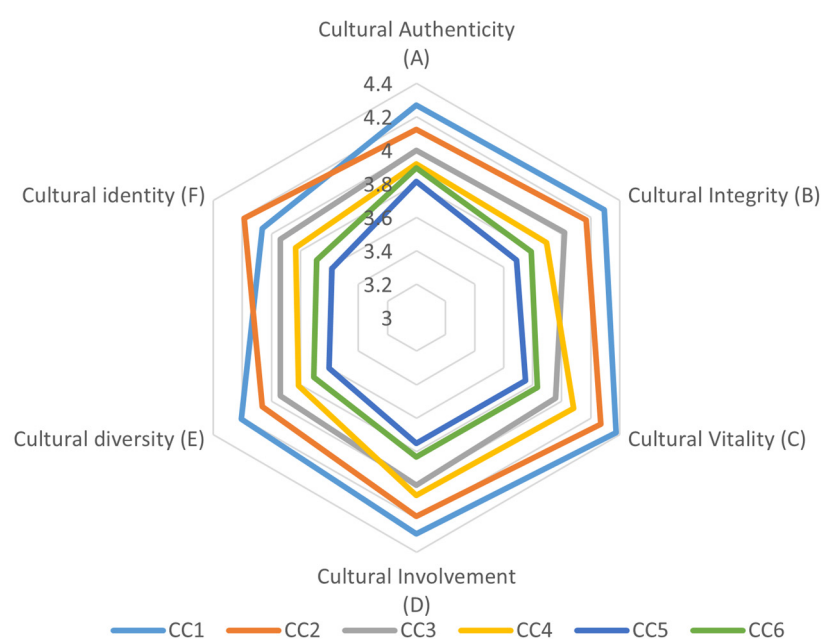


Figure 7. Cultural cognition of Columbia Circle.

The correlation analysis for Columbia Circle reveals that global integration, local integration, connectivity, and control are strongly correlated with authenticity, integrity, vitality, involvement, diversity, and identity. This indicates that the more central, accessible, and connected a gate, the higher the public's comprehensive cultural evaluation of that gate (Table 3).

Table 3. Spearman correlation analysis of Columbia Circle.

	Cultural Authenticity	Cultural Integrity	Cultural Vitality	Cultural Involvement	Cultural Diversity	Cultural Identity
Global Integration	0.943 **	0.943 **	0.829 *	0.829 *	0.943 **	0.829 *
Local Integration	1.000 **	1.000 **	0.943 **	0.943 **	1.000 **	0.943 **
Connectivity	0.943 **	0.943 **	1.000 **	1.000 **	0.943 **	0.886 *
Control	0.812 *	0.812 *	0.899 *	0.899 *	0.812 *	0.754
Visual Entropy	0.543	0.543	0.486	0.486	0.543	0.486

* $p < 0.05$, ** $p < 0.01$, $N = 6$. This correlation is for descriptive purposes only, illustrating the association trends among internal variables in this case, and does not support statistical inference.

Notably, the correlation between global integration and local integration is identical. This precisely captures the coherent, hierarchical spatial logic of Columbia Circle and identifies this place as a well-organized system in which the spatial hierarchy is coherent from the local to the global scale. The extremely high correlation between GI and LI at Columbia Circle is a direct and quantifiable reflection of its spatial structure as a “high-quality social hub.” Spaces with the highest integration with their immediate surroundings, such as the central plaza (CC1), are also the most accessible points from all other locations within the site (high GI), concentrating movement, interaction, and perception onto a dominant core. Conversely, peripheral and less-connected points (like CC5) are segregated at both the local and global levels. There are no “hidden” local centers that are globally isolated, nor are there global shortcuts that bypass local contexts.

4.3. The Start Museum

The spatial configuration results of the Start Museum are shown in Figure 8. SM2 and SM4 possess high global integration, local integration, and connectivity, forming the primary movement routes of the site and marking where the original railway tracks and structures were retained. SM6 has the lowest visual entropy and, along with SM3, it exhibits lower integration and connectivity.

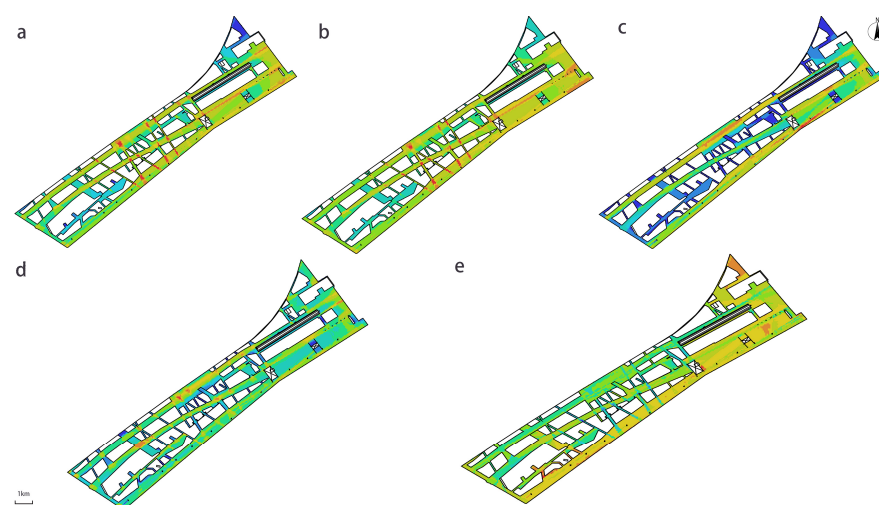


Figure 8. Spatial analysis of the Start Museum with space syntax. (a) Global integration of the Start Museum; (b) Local integration of the Start Museum; (c) Connectivity of the Start Museum; (d) Control of the Start Museum; (e) Visual entropy of the Start Museum.

Regarding cultural cognition, the museum scored lowest in authenticity and identity but highest in vitality. SM2 and SM4 received the highest scores for involvement and diversity, while SM3 and SM6 scored lowest on authenticity and identity (Figure 9).

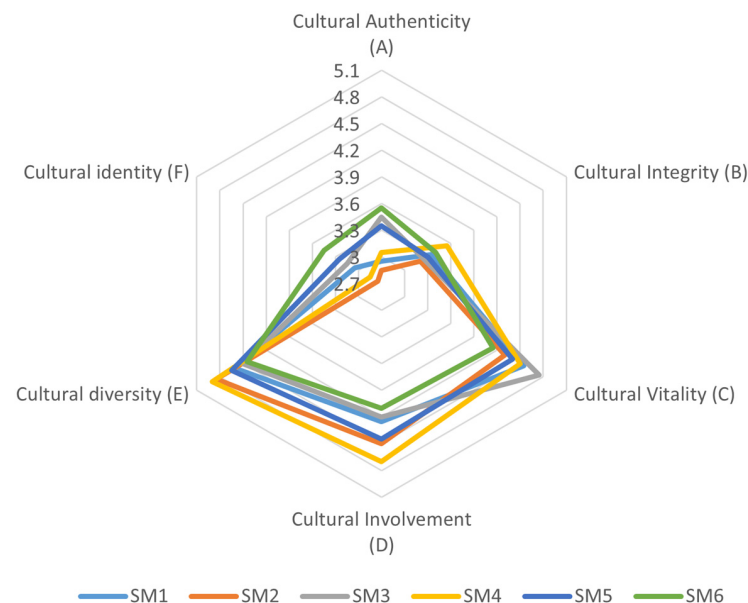


Figure 9. Cultural cognition of the Start Museum.

The correlation analysis indicates that global integration, local integration, and connectivity are all positively correlated with cultural involvement and cultural diversity. This suggests that spaces with high accessibility and connectivity enhance the public's spatial experience.

However, its visual entropy is positively correlated with cultural vitality; their correlation is 1.000. These perfect data precisely reveal the core logic of its revitalized function as a museum. The rank order of the visual entropy scores of the six points is identical to that of their cultural vitality scores. The point with the lowest visual complexity is cognized as the least vital, the second-lowest as the second-least vital, and so on, up to the highest-ranked point for both metrics. This is because the Start Museum's revitalization fundamentally reconfigured the space to serve its new function as a museum. Its setting is highly minimalist and visually clean, where vitality is generated almost exclusively by curated art installations, architectural highlights, and intentionally designed points of interest. These are precisely the elements that increase visual information and, consequently, visual entropy at specific locations. Therefore, this perfect correlation strongly validates the hypothesis that, in a function-driven, minimalist heritage revitalization, visual complexity can become the dominant, or even sole, driver of perceived vitality (Table 4).

Table 4. Spearman correlation analysis of the Start Museum.

	Cultural Authenticity	Cultural Integrity	Cultural Vitality	Cultural Involvement	Cultural Diversity	Cultural Identity
Global Integration	−0.036	0.500	0.214	0.964 **	0.964 **	−0.036
Local Integration	0.071	0.571	0.250	0.929 **	0.929 **	0.107
Connectivity	−0.214	0.250	0.393	0.929 **	0.929 **	−0.214
Control	0.445	−0.148	0.334	0.259	0.259	0.482
Visual Entropy	0.321	0.321	1.000 **	0.393	0.393	0.250

** $p < 0.01$, $N = 6$. This correlation is for descriptive purposes only, illustrating the association trends among internal variables in this case, and does not support statistical inference.

4.4. Influence of Spatial Configuration on Cultural Cognition After Heritage Revitalization

After comparing the three cases, we found that Tianzifang is internally cohesive and visually complex but relatively isolated from its external settings (Table 5). Columbia Circle is hierarchically structured, with a highly open core and a relatively enclosed periphery. The Start Museum features strong internal–external connectivity, clear pathways, and low visual interference, with its revitalized form directly serving its core function as a museum.

Table 5. Comparison of the cases.

	Tianzifang	Columbia Circle	The Start Museum
Global Integration	20.73	34.17	38
Local Integration	35.3	29.46	40.3
Connectivity	1470	5114	5200
Control	5	5.65	3.9
Visual Entropy	14.33	10.92	9.2
Cultural Authenticity	25.15	24.02083	19.2
Cultural Integrity	24.05	23.85417	20.05
Cultural Vitality	23	24.27083	26.65
Cultural Involvement	20.45	24.125	26.2
Cultural diversity	20.05	23.33333	27.95
Cultural identity	21.55	23.29167	18.5

Tianzifang has the lowest global integration, high internal variance in local integration, highly variable visual entropy, and low connectivity and control, yet it scores highest in cultural authenticity and lowest in involvement. This points to an introverted spatial character. Its internal network is highly connected and active, and its visual field is irregular, complex, and information-rich. This structure provides the public with a slow and exploratory experience. The space in this structure is the core of the cultural attraction.

Columbia Circle shows the highest global integration, connectivity, and control but lower and more concentrated visual entropy values than Tianzifang. It scores high in vitality, integrity, and involvement, indicating more regular and orderly public open spaces.

The Start Museum has high global integration, local integration, and connectivity but the lowest visual entropy and control. It scores high in vitality, diversity, and involvement but extremely low in authenticity and identity. This signifies a space that is concise, open, and visually permeable, with gates connecting numerous spaces for maximum accessibility. The revitalization was primarily driven by its new function as a museum. Although certain cultural features of the original site were retained, the underlying logic of its spatial functions was fundamentally reconfigured.

4.5. Patterns of Cultural Cognition After Heritage Revitalization

Through cluster analysis, the 18 observation points can be categorized into three distinct types (Table 6):

Table 6. Characteristics of the cognized patterns.

Indicators	Tianzifang (TZ)	Columbia Circle (CC)	The Start Museum (tz)
Cultural Authenticity	High	High	Very Low
Cultural Integrity	High	High	Low
Cultural Vitality	Low	High	High
Cultural Involvement	Low	High	High
Cultural diversity	Low	High	Very High
Cultural identity	Average	Very High	Low
Global Integration	Low	Very High	High

Table 6. Cont.

Indicators	Tianzifang (TZ)	Columbia Circle (CC)	The Start Museum (tz)
Local Integration	Low	High	High
Connectivity	Low	Very High	Very High
Control	High	High	Low
Visual Entropy	Very High	High	Low

a. The authentic traditional revitalized area.

High visual complexity underpins historical authenticity and integrity, but low integration and control lead to a loss of vitality and involvement. All six gates in Tianzifang, along with CC4 and CC6, fall into this pattern. This demonstrates that spaces with low control, low connectivity, and high visual richness preserve a sense of historical authenticity. However, their narrow alleys and low global accessibility limit deep public engagement and hinder the injection of contemporary vitality.

b. The high-quality social hub.

CC1, CC2, CC3, and CC5 represent this model. High global integration and connectivity establish the space as the center of a community network, thereby supporting growth across all dimensions of cultural cognition. High connectivity is the key attribute, including central plazas, primary intersections, and public service nodes. They constitute hubs of community life, concentrating pedestrian flow, mixed functions, and social interactions. High global integration signifies that these gates are not just local centers but also gateways to the entire system, easily reachable from any point.

c. The functional and vital art container.

All six gates at the Start Museum exemplify this pattern. It primarily uses high control, low connectivity, and low visual interference to create an extraordinary experience, thereby stimulating vitality, involvement, and diversity. However, this space completely divests its historical authenticity and identity.

5. Discussion

The comparative analysis of Tianzifang, Columbia Circle, and the Start Museum reveals that the spatial configuration of revitalized heritage sites is not merely a neutral physical container but an active, determinative force that shapes psychological and cultural cognition. By integrating spatial syntax metrics with multidimensional cultural cognition data, this study found that the spatial attributes designed to maximize contemporary functional efficiency and organized vitality frequently operate in direct opposition to the preservation of historical authenticity and cultural identity. Through the lens of the three distinct models identified in the clustering analysis, this discussion unpacks the complex trade-offs inherent in heritage revitalization (Table 7).

Table 7. Comparison of the three patterns.

Compared Dimensions	Authentic-Traditional Revitalized Area	High-Quality Hub	Functional and Vital Art Area
Spatial Prototype	Community	White-cube art museum	Historic district
Sample Composition	TZ1, TZ2, TZ3, TZ4, TZ5, TZ6, CC4, CC6	SM1, SM2, SM3, SM4, SM5, SM6	CC1, CC2, CC3, CC5
Dominant Spatial Indicator	Visual entropy	Control	Connectivity
Dominant Cultural Dimension	Authenticity/integrity	Vitality/diversity	Identity
Spatial-Cultural Logic	Visual complexity → historical authenticity	Minimum control → contemporary vitality	Network centrality → community identity
Characteristics	Authentic but lacking vitality	Vital but lacking identity	Authentic, vital, identified
Value	Historic preservation value	Contemporary cultural value	Collective memory value
Revitalized Strategy	Activate participation	Inject historical narrative	Strengthen the network centrality

5.1. *The Dual Properties of Visual Entropy: Authenticity Versus Alienation*

The spatial data from Tianzifang highlight the complex role of visual entropy in heritage settings. In environmental psychology and spatial syntax, high visual entropy denotes spatial irregularity, visual clutter, and complex lines of sight. The results indicate that Tianzifang possesses the highest visual entropy, combined with low global integration but highly variable local integration, and creates a highly introverted spatial morphology.

The correlation analysis reveals a fascinating psychological characteristic: although this high visual complexity is inherently linked to high cultural authenticity and cultural vitality, it exerts a significant negative impact on cultural identity. This is because the high visual entropy, due to the narrow alleys, dense signage, and layered historical textures, forces the public to slow down and visually engage with the physical fabric. Thus, it validates the site's age and unpolished reality and guarantees an exploratory, serendipitous experience, which is interpreted as "vitality."

However, when visual entropy crosses a certain threshold without the balancing effect of high global integration, a space becomes illegible. According to Kevin Lynch's theories of urban legibility, when users cannot easily map or navigate an environment, their sense of spatial mastery diminishes [16]. As the data for TZ6 demonstrate, its excessive complexity alienates the public. The space, while historically authentic, transforms into a chaotic spectacle to be observed rather than a community space to belong to. Consequently, the public struggles to develop a deep emotional resonance or territorial attachment, resulting in a loss of cultural identity [38].

5.2. *Influence of Centrality: Spatial Hierarchy as a Holistic Catalyst*

Compared with Tianzifang, Columbia Circle demonstrates a clear spatial hierarchy. The CC1 data are unparalleled because it possesses the highest global integration, local integration, connectivity, and control across all 18 samples, rendering it an essential position.

Crucially, the correlation analysis for Columbia Circle shows that these metrics of spatial configuration share a very positive correlation with all cultural cognition dimensions, including authenticity, integrity, vitality, and involvement. This challenges the assumption that modernization necessarily degrades historical cognition. It proves that a space with high legibility and accessibility can be a "social condenser."

5.3. *The Cost of Control: Functional Implantation and Historical Erasure*

The Start Museum exhibits a highly efficient spatial network, characterized by high global and local integrations, very high connectivity, and the lowest visual entropy. This spatial logic is entirely driven by its newly assigned function as an art gallery, creating clear, obstruction-free circulation routes for consuming art.

However, the correlation results expose a stark psychological trade-off. High spatial control and high integration have a strong positive correlation with modern involvement and diversity, but a severe negative correlation with "cultural authenticity" and "cultural identity." This indicates that the process of structurally optimizing and highly controlling a heritage site to dictate a specific narrative simultaneously strips away its organic ambiguity and multi-layered spatial memories. The low visual entropy creates a "white cube" effect. While this spatial neutralization is functionally successful for a museum, it severs the human connection to the place itself. Visitors recognize the space as an efficient, highly active contemporary container, but they can no longer perceive its soul, resulting in the lowest scores for historical identification. The spatial configuration proves that when functional efficiency becomes paramount, historical identity is often spatially erased.

5.4. Heritage Revitalization Implications

The clustering analysis categorizes the spatial-cognized relationships into three distinct models of revitalization. For urban planners and architects, these findings suggest that spatial interventions must be precisely tailored to the specific cultural goals of a revitalization project.

For projects that prioritize preserving historical atmospheres, designers should deliberately maintain high visual entropy, such as rich textures and complex streetscapes, and rely on local integration rather than drastically opening the area to the global urban grid. However, to mitigate the current lack of “involvement,” micro-interventions should focus on improving the connectivity of internal minor nodes, such as small plazas or intersections, to create localized gathering spaces without destroying integral feelings.

When the goal is to create a vibrant community, maximizing global integration and connectivity is paramount. Designers should establish a clear spatial hierarchy with a strongly defined, highly accessible center, for example, a central plaza, to effectively blend preservation with modern social mixing.

If a heritage site is undergoing a complete functional replacement, designers can utilize high control and low visual entropy to create a highly efficient, distraction-free environment. While this guarantees high visitor participation and modern vitality, planners must be acutely aware that the spatial memory has been spatially neutralized. Therefore, to compensate for the loss of “cultural identity,” the site must rely heavily on high-quality external cultural injections, like exhibitions and events, rather than the spatial fabric itself to attract the public.

6. Conclusions

This study demonstrates that, in urban heritage revitalization, spatial configuration is not a mere neutral backdrop but a highly active determinant of human experience. By quantifying how spatial attributes are recalibrated during revitalization, we visualize and measure the hidden physiological cognition of heritage.

By linking space syntax metrics to six dimensions of cultural cognition, we show that global integration, local integration, and connectivity are the strongest predictors of positive public cognition. Furthermore, our three spatial-cultural typologies illustrate how specific morphological interventions dictate whether a site preserves its historical identity, fosters social mixing, or serves solely as a modern functional vessel. These findings advance urban design theory by demonstrating that morphological variables can serve as leading, quantifiable indicators of cultural impact, effectively moving the discourse of space and culture from an abstract metaphor to an empirically testable framework.

However, the limitations of this study must be acknowledged, as the research is currently at a primary stage. The principal limitation is the relatively small sample size. Consequently, the statistical correlations and clustering results presented herein highlight aggregate-level patterns, and they represent an exploratory analysis rather than definitive causal claims at the individual psychological level. Future work must include a significantly larger number of cases to make the statistical analysis more robust, reliable, and reproducible. Additionally, subsequent steps should incorporate multilevel models and complementary qualitative techniques to further extract the deeper connotations of heritage sites and better understand public cognition.

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