

Article

A Study on the Micro-Spatial Imagery of Communities Under the Background of Rural Spatial Transformation—A Case Study of Naobao Village, Hohhot

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Abstract

Spatial imagery (SI) provides an important framework for understanding how rural spatial transformation affects residents' spatial cognition and supports sustainable rural planning. However, existing studies have mainly examined static spatial sections, with limited attention to longitudinal changes in residents' SI, especially in micro-community spaces. This study takes Naobao village as a case and uses cognitive maps (CMs) and interviews to compare residents' CM drawing processes, SI elements, and SI structures between the old and new villages. The results show that: (1) The old village follows a point-and-line-to-area CM drawing pattern, while the new village shows an area-oriented pattern from local areas to the whole. (2) In terms of SI elements, districts and paths dominate in the old village, whereas districts and landmarks are more prominent in the new village. (3) Regarding SI structure, the old village is mainly characterised by sequential CMs with relatively higher-level structures, while the new village is dominated by spatial CMs with relatively lower-level structures. This study developed a three-dimensional SI framework within the context of rural spatial transformation, which expands the theoretical framework and applicability of the SI model and provides guidance for spatial planning, community renewal, and sustainable development in similar rural tourism destinations.

Keywords: spatial imagery; cognitive map; rural tourism destination; community scale; residents



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1. Introduction

Spatial imagery (SI) refers to the experiential cognitive space that residents form through the influence of the surrounding environment, encompassing both direct and indirect perceptions of the environment. It is an environmental image that can be imagined and recalled in the mind [1], characterized as identifiable, imaginative, pictorial, and situational [2,3]. SI provides an important analytical perspective for revealing the relationship between rural spatial transformation and residents' spatial cognition. More importantly, SI is closely related to community sustainability, as residents' perceptions and memories of space influence their daily activities, place identity, and place attachment. Therefore, the sustainable development of rural communities should not focus only on physical renewal, infrastructure improvement, and livelihood transformation, but also on whether spatial restructuring can sustain local memory, support everyday life, and strengthen community

belonging. In this sense, SI research provides an important reference for understanding and promoting the sustainable development of rural communities. With the development of rural tourism and revitalization strategies, rural tourism destinations are constantly being restructured through village relocation, road reconstruction, and public space reorganization [4]. Comparing the residents' SI of destinations before and after spatial transformation helps reveal the relationship between changes in rural spatial morphology and the evolution of residents' spatial cognition, and clarifies the mechanisms through which spatial restructuring affects residents' daily activities, spatial memory, and place identity. This provides a theoretical basis and practical reference for human-centred spatial optimization, community renewal, and the sustainable development of rural tourism destinations.

Geographically, the study of SI originated from research on urban imagery [5]. In 1960, Kevin Lynch made a major breakthrough in the study of image maps [6], and Appleyard subsequently built on this foundation by classifying cognitive maps (CMs) into two major types: sequential and spatial, thereby triggering a surge of interest in urban SI research [7]. Existing research on SI mainly focuses on the following three aspects: First, foundational studies on SI. These studies primarily focus on the basic types [8,9], constituent elements [1,10], cognitive structures [11], and factors influencing urban SI [12–14]. In an analysis of Beijing residents' SI, Feng Jian proposed the concept of a single-unit CM [15], whereas Huynh et al. introduced a mixed CM through an empirical case study in Canada [16]. Bo et al. focused on the perception and structure of SI in Huacheng Square, Guangzhou [17]. Chaolin et al. [1] and Shen et al. [18] examined the constituent elements and influencing factors of Beijing's urban imagery maps, whereas Zhang Xinhong et al. used questionnaires and hand-drawn CMs to investigate the basic types, constituent elements, and developmental stages of urban residents' spatial cognition in Lanzhou [19]. Second, there are studies on differences in SI. These studies analysed the differences in urban imagery among people from different social classes [20], ethnic groups [21], and genders [10,22]. They also explored the differences in SI among various groups such as inbound tourists [23], university students [5], and local residents [24]. In addition, these studies include research on spatial differences among internal zones in urban imagery [25,26]. Third, process-oriented studies on SI have examined the development and evolution of spatial cognition. Appleyard found that, as residents become increasingly familiar with urban spaces, their CM tends to shift from a sequential type to a spatial type, indicating that the CM can change with varying conditions and possesses a hierarchical structure [5]. According to Golledge's anchor-point theory, spatial cognition in the early stages is concentrated on major anchor points, and in the later stages, the cognition of secondary anchor points develops around these major anchors [27]. Siegel argued that the cognitive process of SI begins with landmarks, proceeds to routes, and finally develops into comprehensive spatial cognition [28].

The introduction of strategies such as beautiful countryside construction, the digital village initiative, and rural revitalization has advanced research on SI in rural areas. Under the influence of driving forces such as policy intervention, planning, and socioeconomic development, traditional rural villages have undergone transformations in their physical landscapes, spatial structures, and residents' cognition, which have been externalized through changes in their material forms [29]. From a geographical perspective, SI provides a highly relevant framework for studying contemporary rural communities. To examine the relationship between the spatial form of traditional villages and the spatial cognition of different users [26], analyse the cognition and differences in rural landscape SI from the perspective of subjective human perception [30], or explore the production and evolution of tourism spaces in ancient towns and villages, the interaction between tourism imagery and tourism space production, and tourism-imagery-oriented strategies for the optimization

and integration of tourism spaces in ancient towns [31], SI offers an appropriate entry point and analytical perspective, providing useful insights for rural spatial governance, village planning, and new countryside construction. However, compared with the extensive body of research on urban SI, studies on SI in rural communities remain relatively scarce.

In summary, existing research still exhibits significant limitations. First, in terms of analytical framework, existing research mainly focuses on the formation process of spatial imagery, cognitive dynamics, and cognitive structure sequence analysis, but a relatively systematic analytical framework has not yet been formed; thus, the comprehensive interpretation of SI is still insufficient. Second, in terms of research scale. Current SI research has mainly focused on national spaces at the macro scale, such as cross-national and cross-cultural contexts, and urban spaces at the mesoscale, such as Beijing, Guangzhou, Nanjing, and Lanzhou; however, research on SI at the micro-community scale still requires further empirical accumulation, especially in rural communities. In addition, both residents and tourists have received scholarly attention; however, the former is more suitable for analysis at the micro-spatial scale of the community. There are two main reasons for this. Residents are more familiar with their community space than with the broader urban space, and only when respondents are sufficiently familiar with the environment can the CM they draw be considered methodologically reliable. Simultaneously, familiar community spaces are closely related to residents' daily lives, and each constituent space is concrete and meaningful in terms of residents' lived experiences. Finally, in terms of research sequence. Existing studies have tended to emphasize analyses of cognitive structural sequences, such as the formation process of SI and dynamic changes in cognition, while paying relatively little attention to the spatial transformation of case areas along a temporal developmental sequence.

In response to these gaps, this study makes three main contributions. First, it constructs a systematic SI analytical framework that integrates three analytical dimensions: CM drawing processes, SI elements, and SI structures. By doing so, this study moves beyond the fragmented examination of single cognitive features and provides a more comprehensive approach to interpreting residents' SI. Second, this study extends the research scale of SI studies from macro-national and meso-urban spaces to the micro-community scale of rural settlements. By taking rural residents as the main research subjects, it emphasises the importance of everyday familiarity and lived experience in shaping spatial cognition, thereby offering more reliable and context-sensitive evidence for understanding SI in community spaces. Third, this study introduces a temporal comparative perspective by examining residents' SI before and after rural transformation. Through the comparison between the old and new village spaces, it reveals how spatial restructuring influences residents' CMs, perceived SI elements, and overall SI structures. Furthermore, the research perspective and SI analysis framework of this study have a certain degree of transferability and replicability, which can provide a reference for rural studies in the context of relocation, reconstruction, tourism development or community renewal, and reveal how changes in physical space reshape residents' SI of the community.

Based on this, this study selected Naobao village, a rural tourism destination, as a case study, extending the research perspective from the traditional mesoscale urban space to the micro-scale rural community space, comparatively analyzing changes in residents' hand-drawn CM processes before and after spatial transformation in rural communities, and further examining the evolution, differences, and underlying causes of SI elements and structures along a temporal developmental sequence, thereby providing new empirical evidence for SI and promoting deeper research on the microscale SI of rural communities. In the following sections, Section 2 details the research methodology. Section 3 describes the analytical results of CM drawing processes, SI elements, and SI structures. Section 4

explores the SI framework and the main reasons for SI evolution characteristics. Section 5 summarizes the main findings of the research.

2. Materials and Methods

2.1. Study Area

Naobao village is located in Baoheshao Town, Xincheng District, Hohhot, China (Figure 1). It was established during the Kangxi reign of the Qing Dynasty and has a history spanning more than 320 years. It was originally formed by migrants from Shanxi who came to reclaim wasteland and settle there and developed into a typical village dominated by traditional agriculture. Old Naobao village is located in the southern foothills of the Daqing Mountains, where the terrain is high in the north and low in the south, making the area prone to frequent flooding. At night on 25 July 2012, a mountain flood destroyed nearly 100 houses in the village, affecting more than 1200 people and plunging villagers' production and daily lives into severe difficulty. In 2013, Naobao village entered a new stage of development, and following the overall ecological construction plan for the southern slope of the Daqing Mountains in Xincheng District, the entire village was relocated through ecological migration to a flatter area farther south. In the same year, the municipal government proposed the development concept of building a “back garden” for the capital of the autonomous region, and Naobao village began to develop rural tourism. The construction of the Naobao village Cultural Tourism Industrial Park began in 2014, and the park officially opened to the public in 2018, soon becoming a popular local tourist destination with its distinctive regional culture and attractive garden landscape. Subsequently, a series of leisure and entertainment facilities were built, including the Chilechuan International Convention and Exhibition Centre, a sightseeing Ferris wheel, an outlet shopping centre, and a water park.

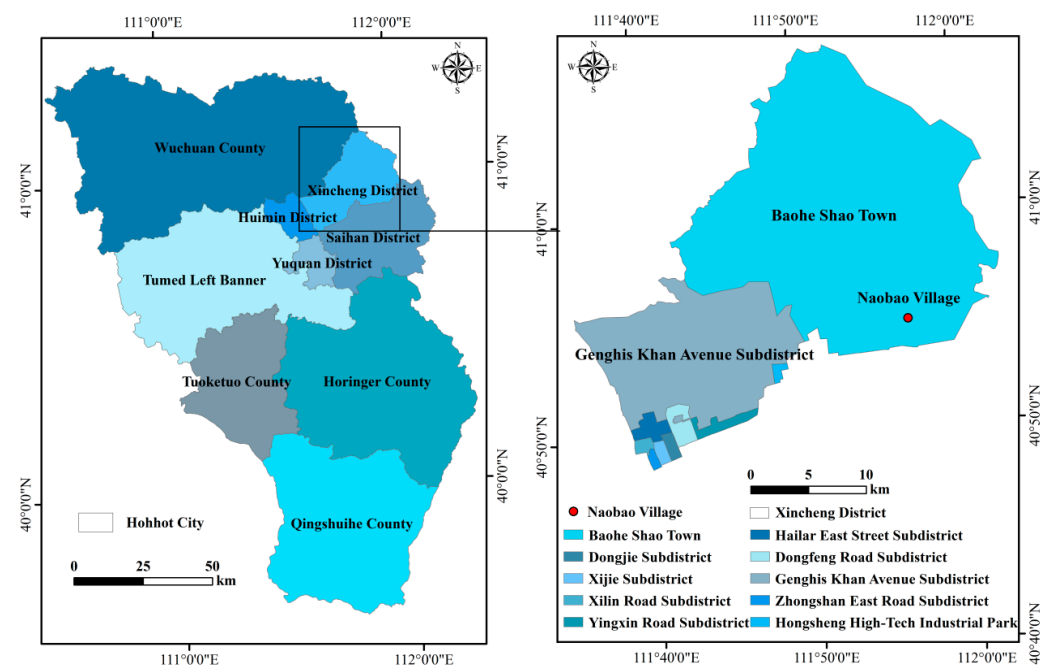


Figure 1. Location map of Naobao village.

Overall, the rural space of Naobao village underwent a dramatic transformation: the entire Old Naobao village was demolished and replaced by the Chilechuan International Convention and Exhibition Centre for commodity exhibitions and tourist visits, while the surrounding farmland was completely converted into the residential areas of New Naobao village and land for tourism reception. As a case study in qualitative research, a case must

possess both typicality and misrepresentations. Under the dual influence of ecological migration and tourism development, Naobao village has experienced significant rural spatial transformation; residents' perceptions of community structure and spatial form have also changed accordingly, making the case highly relevant for research on the SI of rural communities.

2.2. Methods

This study primarily collected data through three approaches—CM, social survey methods, and secondary data collection—and ensured the validity and scientific rigor of the research findings through the cross-verification of multiple data sources (Figure 2).

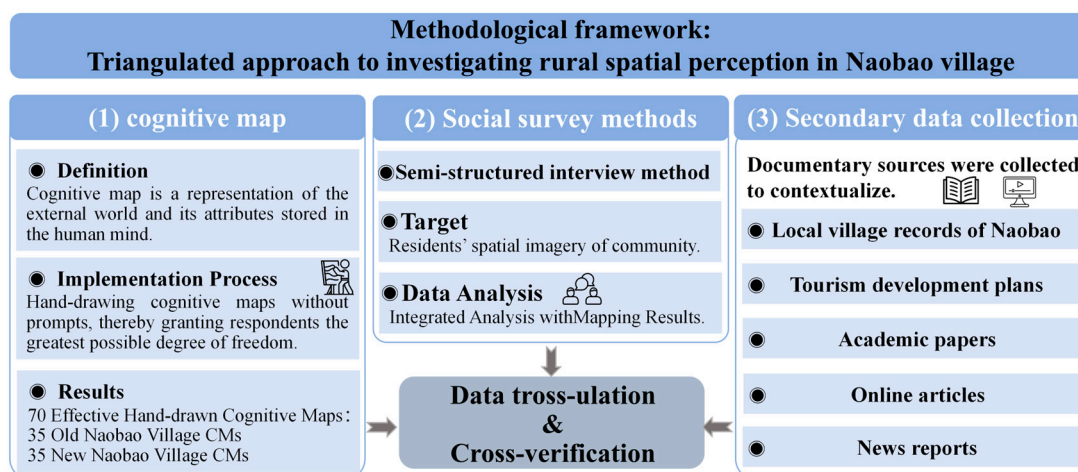


Figure 2. Methodological framework.

- (1). CM. A CM is a representation of the external world and its attributes stored in the human mind [32], and is one of the most effective methods for investigating rural spatial perception; hand-drawn CMs play an important role in revealing people's impressions, cognition, and imagery of a given space. In this study, CM was used to portray residents' perceptions of community micro-spaces. Although previous studies have provided respondents with drawing prompts, such as examples of hand-drawn sketches [33] or typical landmarks [34], this study, following Young's approach [35], deliberately avoided such prompts in order to prevent practice effects arising from mutual cues between instructions and the sketching task [36], thereby granting respondents the greatest possible degree of freedom and enabling a fuller exploration of the elements and types of residents' CMs. The fieldwork for this study was conducted in Naobao village from 1 May to 10 May 2023. Participants were selected according to two main criteria: Firstly, residents who have lived in the village for at least 10 years and who are currently living in Naobao old village, being familiar with the old village. Secondly, residents currently living in Naobao new village and also familiar with the new village. Through random sampling, a total of 35 residents participated in the drawing of the CM, including 16 males and 19 females, with an age range of 19 to 72. The sample was designed to cover residents of different ages, genders, and occupations as much as possible to reduce potential biases caused by relying on a single type of respondent. During the survey, CMs were drawn using a free-drawing approach, in which 35 residents were invited to depict on blank paper their mental impressions of the community space in terms of the form, area, structure, and location of relevant features. Seventy valid CMs were obtained, including 35 maps from old Naobao village and 35 maps from new Naobao village. Furthermore, to ensure the reliability of CM interpretation, a standardized process

was adopted for classification and coding. First, a coding framework was constructed based on existing CM and SI research, including the classification of CM drawing processes, SI elements, and SI structures. Second, two researchers with backgrounds in geography, tourism, and ethnology independently coded the CMs using the same criteria. Third, the coding results were compared, and for CMs with discrepancies, the research team (a total of four researchers) discussed and made the final decision. This procedure helps improve the consistency and reliability of CM classification and interpretation.

- (2). Social survey methods. This study also adopted interview-based survey methods from sociological research to investigate residents' SI of the Naobao village community, and the results were analyzed in an integrated manner.
- (3). Secondary data collection. These materials mainly included the local village records of Naobao; tourism development plans obtained during fieldwork; and academic papers, online articles, and news reports collected through online searches.

3. Results

The SI elements reflect the degree to which residents perceive a destination as legible and imaginable, whereas the SI structure reveals how residents construct spatial relationships among different landscape features within the destination [37]. Therefore, most existing studies regard SI elements and structures as the two principal indicators for interpreting SI. To a certain extent, CM reflects the cognitive outcomes of residents' SI [38], whereas the process of drawing CMs reveals the modes of thinking through which residents organize and construct space; however, the latter has rarely been addressed in empirical research. Residents typically employ different drawing processes to depict community spaces stored in their memory, and analyzing these processes makes it possible to comprehensively examine differences in spatial cognition and distinctive spatial thinking patterns among residents. Based on this, the present study used 70 valid hand-drawn CMs as the primary data source to interpret three dimensions—the CM drawing process, SI elements, and SI structure—and discusses the findings in relation to the research theme.

3.1. Analysis of the CM Drawing Process

This study refers to the five types of CM drawing processes proposed by Lynch in *The Image of the City* [4], as shown in Table 1. Combined with the follow-up survey conducted in Naobao village on residents' community CM drawing processes, this study analyses the drawing processes and characteristics of 35 CMs in old Naobao village and 35 CMs in new Naobao village, and further compares the two sets of CMs, as detailed in Table 2.

Table 1. Classification of CM drawing processes and their spatial characteristics.

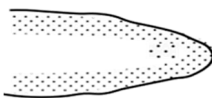
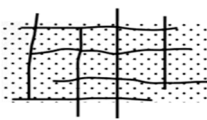
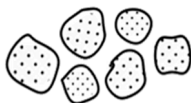
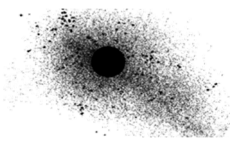
Classification of CM Drawing Processes	Diagram	Characteristics
Type 1: Develops along familiar travel routes and then radiates outward to surrounding areas.		Path-oriented
Type 2: Begins by drawing an outline and then fills inward toward the centre.		Path-oriented
Type 3: Starts with repetitive basic patterns (e.g., a road grid) and then adds detailed features.		Path-oriented

Table 1. Cont.

Classification of CM Drawing Processes	Diagram	Characteristics
Type 4: First depicts a series of adjacent areas, and then illustrates their interrelationships and internal structures.		Region-oriented
Type 5: Begins with a familiar core area or element, to which all other features are subsequently related.		Region-oriented

Note: Compiled by the authors based on reference [39].

Table 2. Classification statistics of CM drawing processes of old Naobao village and new Naobao village.

Rural Community	Type	Number (Maps)	Percentage (%)
Naobao old village	Type 1	20	57.14
	Type 2	4	11.42
	Type 3	3	8.57
	Type 4	2	5.71
	Type 5	6	17.14
Naobao new village	Type 1	5	14.28
	Type 2	2	5.71
	Type 3	1	2.85
	Type 4	18	51.42
	Type 5	9	25.71

3.1.1. Drawing Process of CM of Naobao Old Village

Based on the tracking survey and documentation of the drawing processes of 35 CMs in Naobao old village and in combination with the five types of CM drawing processes, the overall results indicate that the drawing process of CMs in Naobao old village was dominated by Type 1 and supplemented by Type 5, with a marked road-oriented characteristic, as shown in Table 2. The Type 1 CM drawing process is characterized by a road-oriented approach, in which residents generally first depict National Highway 110, which leads into the village, together with the main internal streets such as Village Central Street, West Street, Youfang Street, and Danan Street, and then successively add the remembered elements located around these streets, thereby gradually forming the micro-community space in residents' SI (Figure 3). As shown in Figure 4, the participant represents a typical Type 5 drawing process, which is region-oriented; that is, it begins with a familiar core area or element to which all other features are related. The interviews revealed that the participant had previously worked at the village supply and marketing cooperative. When asked to draw the community space of the old village, the participant first depicted the place with which they were most familiar—the supply and marketing cooperative—followed by the village committee and the opera stage located nearby, then the representative area to the west of the cooperative, including the primary school and dairy collection station, followed by Village Central Street and nearby households adjacent to the cooperative, and finally the Aobao located in the northeastern part of the village, noting that Naobao village derived its name from this landmark.

3.1.2. Drawing Process of CM of Naobao New Village

A classification of the drawing processes of 35 hand-drawn CMs of Naobao new village shows that the CM drawing process of the new village is characterized by a region-oriented pattern, with most cases concentrated in Type 4 and Type 5, as shown in Table 2. Residents

classified as Type 4 generally first outline several adjacent areas, such as residential zones, scenic areas, villa districts, and entertainment zones, and then connect them through a road network while further refining their internal subdivisions (Figure 5). Type 5 accounts for the second largest proportion. As shown in Figure 6, residents first depicted the Naobao Cultural Tourism Area and the residential community opposite it, then successively illustrated the surrounding representative built-up areas around the scenic zone, including the villa district, square, Ferris wheel, Water World, snack street, and village committee, and subsequently used the residential community as the centre to draw nearby shops, the International Convention and Exhibition Centre, and the outlet mall.

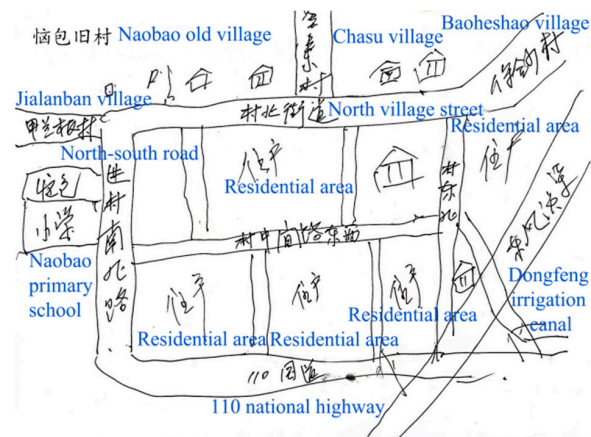


Figure 3. Type 1 CM drawing process.

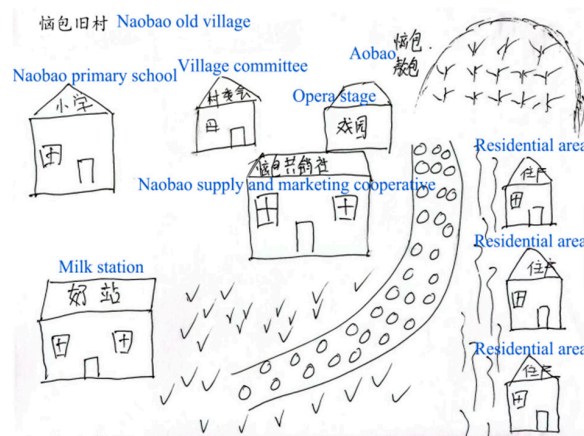


Figure 4. Type 5 CM drawing process.

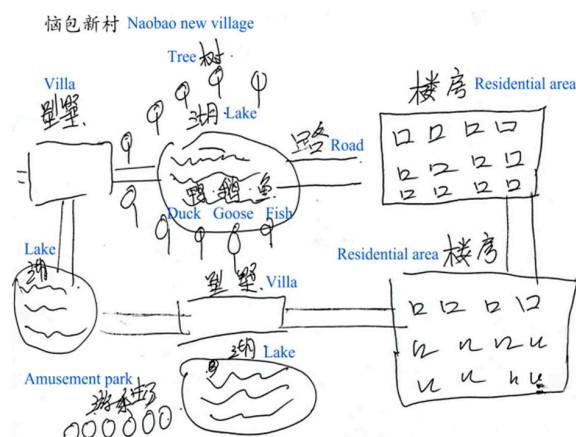


Figure 5. CM drawing process type 4.

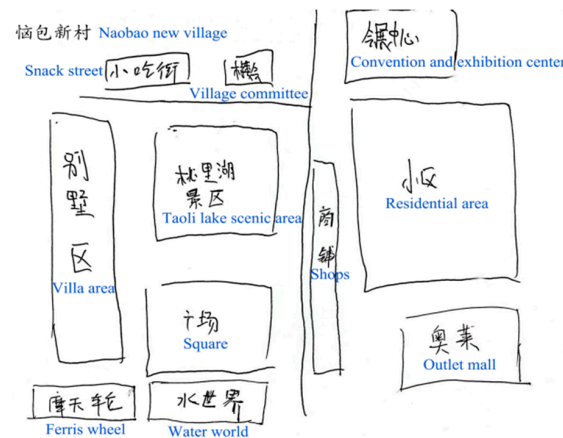


Figure 6. CM drawing process type 5.

3.1.3. Comparison of CM Drawing Processes Before and After the Transformation of Naobao Village

Overall, the CM drawing process of Naobao old village was predominantly road-oriented, whereas that of Naobao new village was mainly region-oriented. This distinction is not only reflected in the frequency distribution of drawing-process types, but also supported by residents' drawing sequences, the spatial elements they selected first, and the ways in which different spaces were connected in their maps.

This difference reflects distinct modes of spatial thinking and spatial organization before and after rural transformation. In Naobao old village, residents tended to begin their drawings from roads or key nodes, indicating a road-oriented mode of spatial thinking and a spatial organization pattern extending from points and lines to areas. By contrast, the CMs of Naobao new village were usually formed by successively outlining and integrating different functional zones according to spatial proximity or familiarity. This indicates a region-oriented mode of spatial thinking and an area-to-area spatial organization pattern, moving from local parts toward the overall community structure. These differences suggest that rural spatial restructuring reshaped not only the physical layout of the village, but also the ways in which residents cognitively organized community space.

3.2. Analysis of SI Elements

Lynch proposed that urban imagery consists of five elements—paths, edges, districts, nodes, and landmarks [39]—the geometric spatial significance of which is fully embodied. Although these elements play different roles in the SI process across different subjects, for groups with similar attributes, the SI characteristics they reflect tend to be relatively stable and reveal the underlying patterns and features of SI. In this survey, the five major elements involved in the 70 hand-drawn CMs were systematically identified, classified, and quantified, and a comparative analysis was conducted on the residents' SI elements in Naobao old and new villages, as shown in Table 3.

3.2.1. SI Elements of Naobao Old Village

All 35 hand-drawn CMs of Naobao old village produced by the residents embodied the five elements mentioned above, as shown in Table 3. District elements showed the highest frequency of occurrence, reaching 97.14% with an average of 3.91 occurrences per CM. These district elements include two categories of features: large-scale areas with clearly defined functions, such as residential areas and farmland, and smaller places closely associated with daily life, such as primary schools, supply and marketing cooperatives, village committees, and clinics. Path elements ranked second in frequency, reaching 91.43% with an average of 2.63 occurrences per map. Most roads in Naobao Old Village were

originally unnamed rural dirt roads and were later paved with concrete. Residents generally depicted typical internal community roads such as Village Central Street, Danan Street, West Street, and Youfang Street, based on their geographical orientation, while a smaller number of residents drew National Highway 110, the main route into the village. Landmark elements appeared with a frequency of 42.85%, averaging 0.80 occurrences per map, and were mainly represented by buildings with distinctive features or important symbolic meanings, such as the Sanguan Temple, South Zhaobi, East Zhaobi, and Aobao. Node elements showed a relatively low frequency of 37.14%, with an average of 0.63 occurrences per map, and usually referred to places characterized by connectivity and concentration, such as the opera stage, milk station, and bridge depicted by residents. Edge elements had the lowest frequency of occurrence (22.86%) and were identified in the hand-drawn CMs of only eight residents. At the micro-community scale, particularly in rural areas where spatial layouts tend to be more dispersed, boundaries are perceived least strongly, and there are relatively few features that clearly demarcate spatial extents. In the CMs of Naobao old village, the only boundary perceived by residents was the Dongfeng Irrigation Canal, which separates the daily living area from the agricultural production area.

Table 3. Classification statistics of SI elements of the old and new villages.

Rural Community	SI Element	Occurrence Count (Times)	Occurrence Frequency (%)	Total Quantity (Units)	Average Quantity (Units per Map)	Occurrence Count of Characteristic Elements (Times)
Naobao old village	Path	32	91.43	92	2.63	Village Central Street (25), Danan Street (14), West Street (9), National Highway 110 (8), Youfang Street (5)
	Edge	8	22.86	8	0.23	Dongfeng Irrigation Canal (8)
	District	34	97.14	137	3.91	Residential area (30), primary school (23), supply and marketing cooperative (20), village committee (18), farmland (12), clinic (8), brick factory (4)
	Node	13	37.14	22	0.63	Opera stage (7), milk station (6), bridge (3)
	Landmark	15	42.85	28	0.8	Sanguan Temple (10), South Zhaobi (6), East Zhaobi (5), Aobao (3)
Naobao new village	Path	16	45.71	26	0.74	Naobao Avenue (15), Snack Street (4)
	Edge	0	0	0	0	
	District	35	100	162	4.62	Residential area (35), cultural tourism area (35), logistics park (13), amusement park area (10), commercial area (9), villa district (8), village committee (8), Outlet Water World (7), outlet mall (5)
	Node	7	20	16	0.46	Stone bridge (4), cultural fitness square (3), Qingcheng Post Station (3), police office (2)
	Landmark	27	77.14	43	1.23	Taoli Lake (13), cultural compound (11), Eye of Naobao—Ferris wheel (9), siheyuan courtyard (4)

Note: Occurrence count refers to the total number of times an element appears in the CMs, occurrence frequency refers to the occurrence count divided by the total number of samples $\times 100\%$, total quantity refers to the total number of individual instances of the element, and average quantity refers to the total quantity divided by the total number of samples.

3.2.2. SI Elements of Naobao New Village

As shown by the statistical results in Table 3, the imagery elements in residents' CMs of Naobao new village comprised four categories—paths, districts, nodes, and landmarks—and no edge elements were identified. District elements appeared at a fre-

quency of 100%, indicating their absolute dominance in residents' SI, and they also had the highest average number, 4.62 per map. After the relocation and reconstruction of Naobao village, its functional zoning became more explicit and diverse, and the residents' SI was correspondingly enriched, including large built-up areas such as residential zones, cultural tourism areas, logistics parks, commercial districts, and villa districts. Landmark elements appeared with a frequency of 77.14%, averaging 1.23 occurrences per CM and became an important imagery component in residents' CMs. At the micro-community scale, the number of typical landmark elements is relatively limited compared with those at the national or urban scale; residents mainly depicted culturally significant compounds, architecturally distinctive siheyuan courtyards, and popular check-in sites such as Taoli Lake and the Eye of Naobao. After the transformation, the frequency of path elements declined to 45.71%, with an average of 0.74 per map, and most residents depicted Naobao Avenue, the main road in front of a residential area. Node elements were perceived to a relatively low degree, with a frequency of 20% and an average number of 0.46, and were mainly represented by places characterized by connectivity and recreational stopping, including the stone bridge, cultural fitness square within the residential community, Qingcheng Post Station, and police office depicted by residents. Edge elements have not yet been perceived by residents, as the residential area of Naobao new village is integrated with other functional zones, with production and daily life closely intertwined, forming a new rural community that integrates residence, tourism, and commerce; consequently, there are still no clearly demarcated and visually prominent edge elements.

3.2.3. Comparison of SI Elements Before and After the Transformation of Naobao Village

Overall, the spatial restructuring of Naobao village reshaped the hierarchy of residents' perceived SI elements. In the old village, districts and paths were the dominant elements, while landmarks and nodes occupied secondary positions, and edges were the least prominent. In the new village, districts became overwhelmingly dominant, landmarks gained greater importance, whereas paths and nodes became less prominent in residents' SI.

Specifically, (1) regarding path elements, both the frequency of occurrence and average number per hand-drawn CM in Naobao old village were significantly higher than those in Naobao new village. As the physical space of Naobao village transformed from a traditional community space woven together by rural paths into a modern community space characterized by interconnected functional zones, residents' dependence on roads decreased and their perception of path elements gradually weakened. (2) Regarding edge elements, due to the micro-scale of this study, Kevin Lynch's definition of edges as boundaries separating two areas in urban space is clearly not fully applicable to community space; in this study, edges generally refer to physical features that divide different activity areas, such as spaces for production and daily life. In Naobao old village, the Dongfeng Irrigation Canal served as the boundary between the agricultural production zone and the residential living zone, whereas in Naobao new village, different functional zones and production-living spaces were integrated within the same territorial range without clear boundary divisions; therefore, no edge elements appeared in the hand-drawn CMs of the new village. (3) Regarding district elements, the frequency of occurrence in the CMs of the new village was higher than that in the old village, and the total number increased from 137 in the old village to 162 in the new village. After Naobao village was reconstructed through a top-down process led by dominant actors, such as the government and planning companies, its functional zoning became more explicit and larger in scale, and district elements became more important in residents' SI and shifted toward places occupying larger areas. (4) Node elements appeared with low frequency in the hand-drawn CMs of both Naobao new village and old village; moreover, the classification of

nodes in this study goes beyond the conventional scope of urban imagery research and is made more concrete by adapting it to the micro-scale of the case area, defining nodes as places characterized by connectivity and concentration or as locations where residents may stop and engage in recreation, such as the opera stage and milk station depicted by old village residents, and the stone bridge, Qingcheng Post Station, and police office perceived by new village residents. (5) Regarding landmark elements, their frequency of occurrence in the CMs of the new village was far higher than that in the old village, increasing from 42.85% to 77.14%. After the reconstruction of Naobao village, it evolved from an agricultural community into a tourism-oriented community, with increases in rural image features, major attractions, and iconic buildings. Residents' familiarity with these features and recognition of their importance have also been progressively strengthened with the development of rural tourism.

Beyond changes in frequency, the relationships among SI elements were also reorganized after the spatial restructuring of Naobao village. In the old village, residents' SI was mainly structured by a district–path relationship: paths served as the basic spatial framework connecting residential areas, farmland, public facilities, and daily activity places, while landmarks and nodes, such as the Sanguan Temple, opera stage, and village committee, were embedded along these routes as secondary reference points. In contrast, the new village was mainly characterized by a district–landmark relationship. Clearly planned functional zones, including residential, scenic, commercial, and recreational areas, became the main spatial units through which residents understood the community, while landmarks such as the Naobao Cultural Tourism Area, the Ferris wheel, Water World, and the outlet mall served as symbolic anchors. Meanwhile, paths became secondary connectors between functional zones, nodes remained marginal, and edge elements disappeared due to the integration of different functions within the same community space. This indicates that rural spatial restructuring reshaped not only the prominence of individual SI elements, but also the ways in which these elements were connected and interpreted in residents' SI.

3.3. Analysis of SI Structure

Through careful interpretation and induction of 35 CMs from Naobao old village and 35 CMs from Naobao new village, and with reference to the detailed classification of hand-drawn CMs proposed by Appleyard [5], this study conducts an analysis of the SI structure. The classification results show that the residents' SI structures of community space in Naobao village can broadly be divided into three categories. A comparative analysis of the SI structure of Naobao old village and Naobao new village is presented in Table 4.

Table 4. Classification statistics of SI structure of the old and new villages.

Rural Community	Type	Number (Units)	Percentage (%)	Sub-Type	Number (Units)	Percentage (%)
Naobao old village	Sequential CM	20	57.14	Fragmented type	7	20
				Chained type	10	28.57
				Branch/ring type	3	8.57
	Spatial CMs	14	40	Scattered type	5	14.28
				Mosaic type	5	14.28
				Connected type	2	5.71
				Patterned type	2	5.71
	Individual CMs	1	2.86			

Table 4. Cont.

Rural Community	Type	Number (Units)	Percentage (%)	Sub-Type	Number (Units)	Percentage (%)
Naobao new village	Sequential CMs	9	25.71	Fragmented type	4	11.4
				Chained type	2	5.71
				Branch/ring type	3	8.57
	Spatial CMs	24	68.57	Scattered type	16	45.71
				Mosaic type	3	8.57
				Connected type	3	8.57
				Patterned type	2	5.71
	Individual CMs	2	5.71			

3.3.1. SI Structure of Naobao Old Village

Among the hand-drawn CMs of Naobao old village produced by residents, sequential CMs were dominant, accounting for the highest proportion (57.14%). Spatial CMs ranked second, accounting for 40%, while only one individual CM was identified, accounting for 2.86%. Further details are presented in Table 4.

(1) Sequential CMs

Sequential CMs were the main imagery structure through which residents perceived the old village. A total of 20 sequential CMs were identified, including fragmented, chained, and branch/ring sub-types. Fragmented CMs (Figure 7a) were usually organized along familiar roads and represented partial spatial segments of the community, with seven cases accounting for 20% of the sample. Chained CMs (Figure 7b) linked adjacent areas through multiple roads and appeared most frequently, with ten cases accounting for 28.57%. Branch/ring CMs (Figure 7c) were based on branch-like or ring-like road frameworks and required a more integrated understanding of the village's road system; only three such maps were found, accounting for 8.57%.

(2) Spatial CMs

There were 14 spatial CMs, accounting for 40% of the total sample, which could be divided into four sub-types. Scattered CMs (Figure 7d) consist of spatial features that are dispersed yet possess identifiable areal extents, with their relative positions indicated by squares, circles, and similar symbols. In these CMs, residents mainly depicted important places within the community. Five such maps were identified, accounting for 14.28% of the sample. Mosaic CMs (Figure 7e) mainly refer to maps in which residents subdivide the community into several subareas according to regional differences; this sub-type also comprises five maps. Connected CMs (Figure 7f) are maps in which residents form an imagined space through the effective linkage of different areas; two such maps appeared in the sample, accounting for 5.71%. Patterned CMs (Figure 7g) indicate that residents grasped the overall spatial layout of the community and were able to accurately connect and organize its subareas through dominant elements such as districts and roads, thereby forming complete and accurate CMs.

(3) Individual CMs

Individual CMs (Figure 7h) symbolize residents' perceptions and understanding of the overall physical space through the depiction of concrete or representative individual buildings. For example, one resident drew a courtyard composed of single-storey houses, vegetable gardens, and domestic poultry. Only one map belongs to this category, accounting for 2.86% of the total sample.

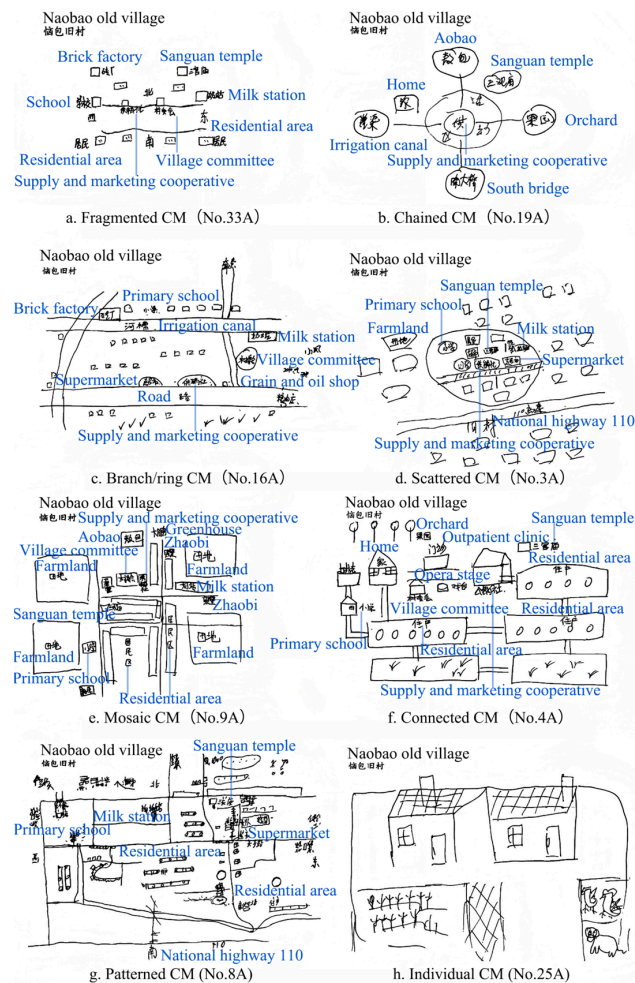


Figure 7. Residents' hand-drawn CMs of Naobao old village.

3.3.2. SI Structure of Naobao New Village

After the spatial restructuring of Naobao village, spatial CMs became dominant in residents' SI structure of the new village, accounting for 68.57% of the total sample. In contrast, the proportion of sequential CMs declined to 25.71%, while individual CMs remained the least common, accounting for 5.71% (Table 4).

(1) Sequential CMs

Nine sequential CMs were identified. Influenced by the environmental characteristics and spatial layout of the new village, the number of road-oriented sequential CMs decreased, accounting for only 25.71% of the total sample. Fragmented CMs (Figure 8a) were organized along roads and marked major spatial features, with four cases accounting for 11.43%. Chained CMs (Figure 8b) linked places such as the residential area, Taoliyuan Scenic Area, and cultural compounds through roads, but only two such maps were found. Branch/ring CMs (Figure 8c) connected roads around the community to form a ring-shaped route, with three cases accounting for 8.57%.

(2) Spatial CMs

Spatial CMs accounted for the highest proportion, reaching 68.57%, with a total of 24 maps. Scattered CMs (Figure 8d) were the most common, with 16 cases. In these maps, residents usually placed iconic buildings or major places across the worksheet, often representing them by names. In the mosaic CMs (Figure 8e), residents assembled and combined different spatial blocks to construct their imagined community space of the new village, and three such maps were identified, accounting for 8.57% of the sample. In the connected CMs (Figure 8f), residents effectively linked spatial fragments of different functional zones

through roads to form a complete imagined space; three residents produced this type of SI structure. Patterned CMs (Figure 8g) not only depict the overall spatial pattern but also outline the contours of different areas, such as the residential area, outlet mall, Water World, and the Eye of Naobao (Ferris wheel), and were relatively rare, with only two maps.

(3) Individual CMs

Individual CMs (Figure 8h) were the least common, with only two cases in the sample, accounting for 5.71%. The two women who produced this type of map depicted the newly built residential area as a symbol of their SI of the new community, indicating that the new apartment buildings held representative significance for residents. Interviews also revealed that residents were most deeply impressed by the newly built apartments after reconstruction: “We never imagined that one day ordinary villagers like us could live in new apartment buildings just like city people. This is the best outcome, and we are all very happy.” (No. 25, outlet mall staff member, female) At the same time, this also reflects that home continues to occupy a place in residents’ minds.

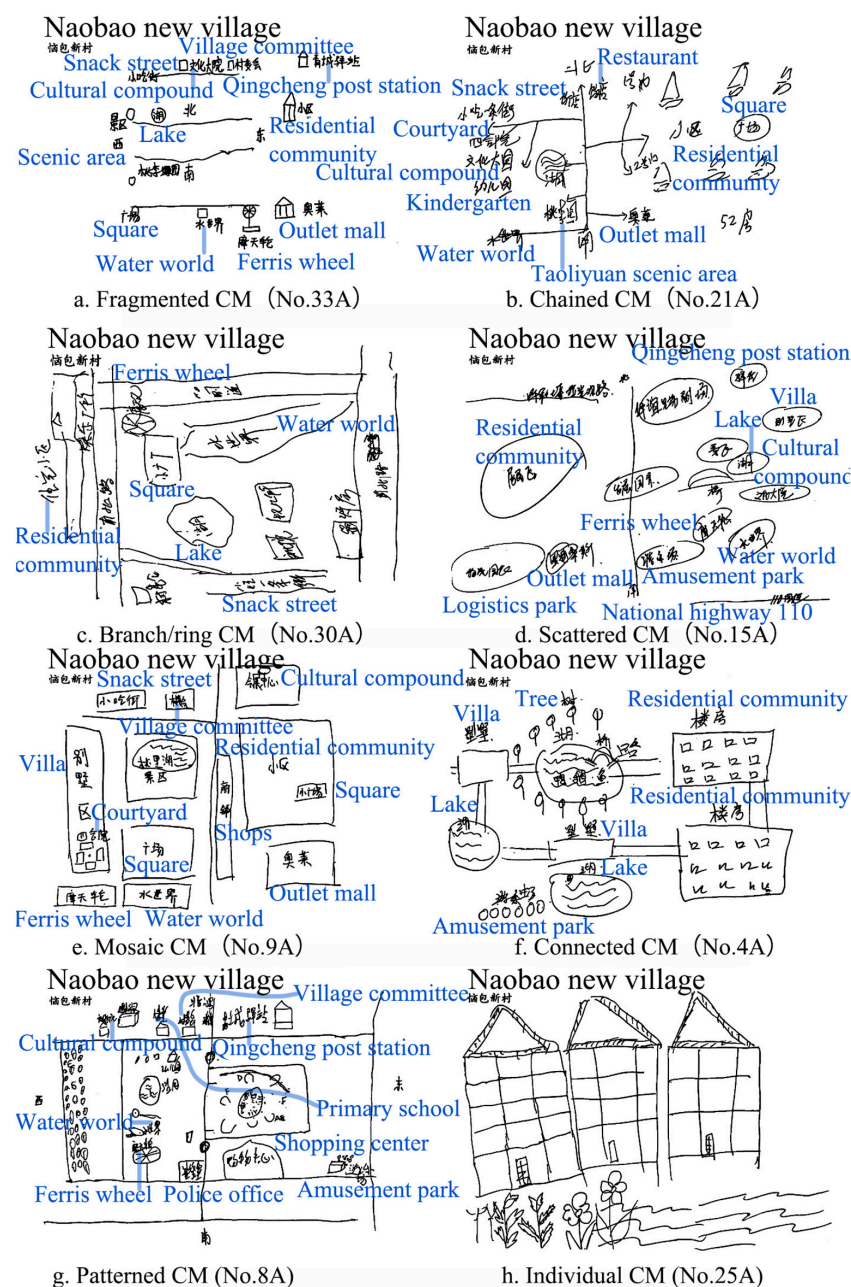


Figure 8. Residents’ hand-drawn CMs of Naobao new village.

3.3.3. Comparison of SI Structures Before and After the Transformation of Naobao Village

In terms of the types of imagery structures reflected in CMs, Naobao old village was dominated by sequential CMs, whereas Naobao new village was dominated by spatial CMs. In Naobao old village, owing to inconvenient transportation, residents' leisure activities were more concentrated within the village itself. In particular, both sides of the main village roads and the shaded areas along rural paths became important places for chatting and playing cards during agricultural slack seasons and after meals. At the same time, residents relied more heavily on public transportation for travel. Consequently, path-oriented sequential CMs occupied an absolute dominant position in the residents' hand-drawn CMs of community space. After the village-wide relocation and reconstruction of Naobao Village, the overall layout became more orderly and standardized, with Naobao Avenue serving as a dividing line and functional zones, such as residential, tourism, and commercial areas, distributed on either side. Land use types were clearly defined, and the functional layout became more distinct. Moreover, with the development of transportation and the economy, residents' travel modes became more diversified, and their dependence on public transportation declined significantly. This, in turn, weakened residents' perceptions of paths while strengthening the imageability of spatial districts.

In terms of the perceptual level of CMs, studies by Appleyard [5] and Lee and Schmidt [40] have suggested that, among sequential perceptual maps, fragmented maps represent a lower-level type, whereas chained and branch/ring maps represent higher-level types. Among spatial perceptual maps, scattered maps are considered lower-level, whereas mosaic, connected, and patterned maps are regarded as higher-level types. Individual element perceptual maps constituted a special category; because they occurred infrequently in this study, no distinction was made regarding their relative levels. Based on Tables 2–4, it can be concluded that Naobao old village contained 21 higher-level CMs, accounting for 60% of the sample, whereas Naobao new village contained 20 lower-level CMs, accounting for 57.14% of the sample. Residents of Naobao old village mainly relied on a semi-industrial and semi-agricultural livelihood pattern, and the separation between workplace and residence was common; thus, their spatial mobility was relatively strong, their overall activity paths were comparatively complex, and their spatial constraints were weaker, leading to a relatively higher level of community space perception. After reconstruction, the vast majority of residents were able to work close to home, finding employment in the village's scenic areas, property management services, and logistics parks. Thus, the separation between workplace and residence became less common, spatial mobility weakened, overall activity paths tended to become more homogeneous, and spatial constraints were strengthened, resulting in a relatively lower level of community space perception among residents.

In terms of different age groups, residents' life experiences, spatial use patterns, and memory accumulation influenced the structure of their SI. Older residents tended to draw sequential CMs for both the old and new villages. They were usually able to clearly recall the location, direction, and names of roads, such as Youfang Street and Danan Street in the old village, indicating that their spatial cognition was mainly based on long-term life experience and everyday walking routes. In contrast, younger respondents were more likely to draw spatial CMs. Although their memories of specific road names and path relationships in the old village were relatively weak, they could clearly identify important public nodes, such as the opera stage, primary school, and Sanguan Temple. In their cognition of the new village, they also showed a clearer understanding of functional zones, such as residential, commercial, and scenic areas. These findings suggest that older residents relied more on paths and sequential relationships to organize their spatial cognition, whereas younger residents tended to understand village space through public nodes, landmark places, and functional zones.

4. Discussion

4.1. Spatiotemporal and Triadic Analytical Framework of SI

The temporal dimension of SI mainly manifests in two aspects. On the one hand, it is reflected in the dynamic changes in the perceptions of the subject of SI (i.e., people) across different time periods. For example, Yufeng et al. [35] comparatively analyzed the changes in Chinese tourists' SI in South Korea before and after their trips to examine the patterns of spatial cognition and evolution of SI [35]. However, the object of the SI (i.e., destination) also changes over time. In the development of dynamic modernizing regions, the rhythm of a sequence is of great importance, just as we remember the melody of music, rather than individual notes [37]. However, existing studies on the subjects and objects of SI, especially those concerning the object of SI, have generally adopted a cross-sectional rather than a diachronic perspective. Therefore, this study investigates the temporal evolution of the SI of Naobao old village and Naobao new village in the context of rural spatial transformation, not only addressing the gap identified by Song Weixuan and others concerning the insufficient examination of SI evolution across different temporal cross-sections [38], but also extending the spatial scope of previous research into the longitudinal dimension.

The spatial dimension of the SI is reflected in the spatial scale of the destination. Geographers have paid attention to the scale effect of CMs; however, most existing studies have focused on the city as a whole, with relatively little research addressing SI at the micro-community scale. By examining the community SI of Naobao village as a rural tourism destination, this study addresses the limitations of previous research constrained by the macro-level orientation of urban-scale studies, which has made an in-depth and fine-grained analysis difficult. At the same time, rural tourism destinations represent a type of vernacular space in contemporary China characterized by distinctive features and complex contexts [41], and research on their community SI elements and structures helps address the relative paucity of studies on the locality of vernacular space.

Theoretically, this study contributes to SI research by emphasizing that SI is not only a cognitive representation of a relatively stable spatial environment, but also a dynamic outcome shaped by changes in the spatial object itself. Previous SI studies have mainly focused on urban spaces or cross-sectional comparisons, whereas this study introduces a diachronic perspective into the analysis of rural community space. Moreover, it develops a systematic SI analytical framework that integrates three dimensions: CM drawing processes, SI elements, and SI structures. This framework helps reveal not only what residents perceive, but also how they organize, express, and reconstruct spatial cognition. In this way, the study extends SI research from urban macro-spaces to rural micro-community spaces and provides a more comprehensive perspective for understanding the reconstruction of spatial cognition during rural spatial transformation.

4.2. Environmental Characteristics and the Cognitive Mechanism of SI Change

Differences in SI are influenced by two aspects: the environmental characteristics of the cognitive object and the individual attributes of the cognitive subject [42]. Within the same cognitive group, the environmental characteristics of the destination often dominate the differences in the elements and structures of CMs [20]. For example, Kevin Lynch found that differences in urban spatial structure are usually accompanied by differences in the dominant elements of residents' CMs; residents in Boston mainly represented SI through districts, those in Jersey City mostly portrayed urban spaces along major roads, and residents in Los Angeles frequently depicted the road system. Cao and colleagues found that Tsinghua University has a highly integrated road network organized around major traffic axes, and therefore students tend to anchor their perception of the campus

environment through path elements; in contrast, the lower integration of the road network at Peking University leads to a decline in students' cognitive clarity and accuracy regarding the campus environment [43]. In addition, many other scholars have supplemented and further developed, through case-based studies and academic inquiry, the view that environmental characteristics shape residents' cognition of SI [12,44].

In this study, all 35 respondents were community residents, and each participant drew CMs of both the old and new villages. This research design reduced, to some extent, the influence of differences among cognitive subjects. Therefore, the changes in CM types, SI elements, and SI structures can be mainly interpreted in relation to the spatial transformation of Naobao village. Naobao old village represents a typical northern rural community formed through a bottom-up development process, characterized by crisscrossing rural paths and courtyard houses built along streets. More importantly, the main activity spaces in the old village were largely distributed successively along the principal streets, and this spatial structure strengthened residents' cognition of the path elements. By contrast, under a top-down reconstruction process driven by dominant institutional forces, Naobao new village developed a regular spatial layout with clearly defined functional zoning, in which each area serves a specific purpose, such as residential, commercial, scenic, and logistics zones; these environmental characteristics led residents to regard district elements as the core of SI. Thus, it can be concluded that the environmental characteristics of a destination and its inherent spatial layout are important factors that shape differences in residents' SI. As a result, residents' SI shifted from a path-oriented structure based on everyday routes to a district- and landmark-oriented structure shaped by planned spatial order. This indicates that spatial transformation may reshape residents' SI by changing the spatial form, functional layout, daily activity settings, and cognitive anchors of the village. More broadly, this finding provides implications for rural spatial planning and community sustainability development. It suggests that spatial restructuring should not be evaluated only in terms of physical order, functional efficiency, or visual improvement, but also in terms of how residents perceive, remember, and organize space in everyday life. Residents' SI can therefore serve as a useful reference for assessing whether a new spatial layout maintains local memory and supports daily activities. From this perspective, SI research helps guide more human-centred spatial renewal and contributes to the sustainable development of rural communities.

It should be noted that the empirical evidence of this study directly demonstrates the differences in residents' CM types, SI elements, and SI structures between the old and new villages. The explanation that spatial transformation reshaped residents' spatial cognition is an interpretation based on comparative CMs, interview materials, and the observed changes in spatial layout. Future studies could further examine this mechanism through longitudinal tracking, behavioral observation, larger comparative samples, or mixed methods combining CMs with GPS-based activity data.

4.3. Planning Suggestions for Sustainable Rural Transformation

The findings provide planning implications for both the renewal of Naobao Village and the sustainable transformation of similar rural tourism communities.

For Naobao village, future planning could focus on two aspects. First, because the old village has already been demolished, its spatial memory should be preserved through symbolic and narrative approaches, such as oral history collection, historical photographs, community memory walls, old-object displays, and small-scale exhibitions. These methods can help record former daily routes, public spaces, production spaces, and important village nodes, thereby maintaining the continuity of local memory and strengthening residents' place identity. Second, the new village should continue to improve its clear spatial zoning

while strengthening its landmark system and tourism image. Clearly defined residential, commercial, scenic, recreational, and service areas can enhance spatial legibility, while recognizable landmark buildings and public spaces can improve the attractiveness of Naobao village as a rural tourism destination. Meanwhile, these landmarks should be connected with local culture and residents' daily life rather than serving only as tourist symbols. Integrating tourism spaces with community life can help balance visitor needs, residents' well-being, and long-term local development.

For similar rural communities undergoing spatial restructuring, planning should balance spatial renewal, functional coordination, and the preservation of local community culture. Rural reconstruction should not be understood merely as physical improvement or functional zoning, but as a process closely related to cultural inheritance, community life, and local identity. Planners should identify traditional culture, historical memories, local customs, and residents' everyday activity spaces, and integrate these elements into spatial layout, landscape design, public facilities, and community activity spaces. More importantly, residents should be involved in planning and renewal decisions so that spatial transformation can enhance community attachment, cultural continuity, quality of life, and the sustainable development of rural tourism.

4.4. Limitations and Suggestions for Future Studies

This study has some limitations. First, this study mainly focuses on the descriptive analysis of SI, and the resulting conclusions tend to remain at a relatively superficial level, lacking both diagnostic research on SI—particularly in terms of its practical implications for spatial planning—and evaluative research concerning the special emotional attachment of imagery subjects to the destination space. In other words, the potential for subsequent research to inform planning practices and enhance community livability requires further exploration. Second, the sample size was relatively small because the study focused on a small rural community and required participants to be familiar with both the old and new village spaces. Therefore, the findings should be interpreted as analytical rather than statistical generalization. Future studies could expand the sample size, include more diverse residents, and compare multiple rural communities undergoing spatial transformation to further test the applicability of the proposed SI analytical framework. Finally, the hand-drawn CMs of the old village may have been influenced by memory reconstruction and recall bias. Future studies could further incorporate multiple sources of evidence, such as historical photographs, old village planning maps, archival records, remote-sensing images, local chronicles, and villagers' oral histories, to cross-validate the SI presented in residents' hand-drawn CMs, thereby enhancing the reliability and explanatory power of the research findings.

5. Conclusions

(1) The CM drawing processes of Naobao residents reveal different modes of spatial thinking before and after rural reconstruction. In Naobao old village, residents' CMs were mainly dominated by type 1 and supplemented by type 5, showing a road-oriented pattern in which spatial cognition extended from points and lines to areas. In contrast, CMs of Naobao new village were mainly concentrated in types 4 and 5, indicating a region-oriented pattern formed through the successive delineation and integration of functional zones according to spatial proximity and familiarity.

(2) Clear differences were found in residents' perception of SI elements between the old and new villages. In Naobao old village, the perceived SI elements were ranked as districts, paths, landmarks, nodes, and edges, with districts and paths playing dominant roles. In Naobao new village, districts became the most dominant SI element, landmarks also held an

important position, while paths and nodes became less prominent. However, edge elements remained weak due to the lack of clearly defined and visually distinctive boundaries.

(3) The SI structure of Naobao village changed significantly after spatial restructuring. Naobao old village was mainly characterised by sequential CMs, reflecting residents' stronger spatial mobility, more diverse activity paths, and higher perception of community space. By contrast, Naobao new village was dominated by spatial CMs, as residents' daily activities became more concentrated within the community and their movement patterns became more homogeneous. In addition, individual-element CMs centred on the home appeared in both villages, indicating residents' emotional attachment to domestic spaces and their sense of place.

This study proposes a three-dimensional SI analysis framework: CM drawing processes, SI elements, and SI structures. This framework transcends fragmented analysis of individual cognitive characteristics, providing a more systematic approach to understanding how residents perceive, organize, and interpret rural community space. By extending SI research from the macro-level of the nation and the meso-level of the city to the micro-level of rural settlements, this study emphasizes the role of everyday familiarity, life experience, and place attachment in shaping residents' SI during rural transformation. Although the framework originates from a case study of Naobao village, its three dimensions capture the general process by which residents construct spatial cognition in a constantly changing community environment, thus possessing potential for generalization and replication. Therefore, this framework can provide a useful reference for research on rural communities undergoing relocation, reconstruction, tourism development, suburbanization, or community renewal. Future research could further test and refine this framework through comparative studies of different types of rural communities, such as traditional villages, suburban villages, ethnic minority villages, and tourism-oriented villages, as well as through cross-cultural comparisons across different regional contexts.

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Abbreviations

The following abbreviations are used in this manuscript:

SI Spatial imagery
CM Cognitive map

References

- Gu, C.; Song, G. Research on urban image space and its constituent elements in Beijing. *Acta Geogr. Sin.* **2001**, *01*, 64–74.
- Hou, Y.; Qu, Y.; Zhao, Z.; Shen, J.; Wen, Y. Residents' Spatial Image Perception of Urban Green Space through Cognitive Mapping: The Case of Beijing, China. *Forests* **2021**, *12*, 1614. [[CrossRef](#)]
- Luo, J.; Shi, J.; Wei, J. Cognitive mapping and map-making: An alternative digital model for the interpretation and presentation of historic urban district. *Front. Archit. Res.* **2026**. [[CrossRef](#)]
- Dai, M.L.; Fan, D.X.F.; Wang, R.; Ou, Y.H.; Ma, X.L. Does rural tourism revitalize the countryside? An exploration of the spatial reconstruction through the lens of cultural connotations of rurality. *J. Destin. Mark. Manag.* **2023**, *29*, 100801. [[CrossRef](#)]
- Li, X.; Song, W.; Wu, W.; Ma, Y. Research on urban spatial perception in Beijing based on tracking survey: A case study of postgraduate students from University of Chinese Academy of Sciences. *Prog. Geogr.* **2020**, *39*, 276–285. [[CrossRef](#)]
- Lynch, K. *The Image of the City*; MIT Press: Cambridge, MA, USA, 1960.
- Appleyard, D. Styles and Methods of Structuring a City. *Environ. Behav.* **1970**, *2*, 100–117. [[CrossRef](#)]
- Wang, M.; Li, G. Research on Medium-scale spatial image Based on Urban Image Theory: A case study of Northeast Normal University. *J. Northeast. Norm. Univ. (Nat. Sci. Ed.)* **2015**, *47*, 128–134.
- Huo, T.; Wang, M. Spatial structure of urban cognition based on place name recognition rate in Beijing. *Prog. Geogr.* **2009**, *28*, 519–525.
- Son, Y.; Yoo, J.; Lee, I. Cognitive and Structural Perspectives on a Traditional Terraced Rice Field Village: An Integrated Spatial Syntax Approach. *Land* **2025**, *14*, 1634. [[CrossRef](#)]
- Liu, Y.; Yu, G. A detailed study on the restoration and change of ancient spatial image in Chaoyangmen area of Beijing Old City. *Archit. J.* **2022**, *S2*, 117–122.
- Liu, H.; Hu, X.; Ai, X. Spatial image characteristics of tourists in urban forest parks: A case study of Forest Botanical Garden in Hunan Province. *Econ. Geogr.* **2014**, *34*, 171–176. [[CrossRef](#)]
- Self, C.M.; Golledge, R.G. Sex-related differences in spatial ability: What every geography educator should know. *J. Geogr.* **1994**, *93*, 234–243. [[CrossRef](#)]
- Imani, F.; Tabaeian, M. Recreating mental image with the aid of cognitive maps and its role in environmental perception. *Procedia-Soc. Behav. Sci.* **2012**, *32*, 53–62. [[CrossRef](#)]
- Feng, J. Spatial perception and image spatial structure of urban residents in Beijing. *Sci. Geogr. Sin.* **2005**, *2*, 142–154.
- Huynh, N.T.; Hall, G.B.; Doherty, S.; Smith, W.W. Interpreting urban space through cognitive map sketching and sequence analysis. *Can. Geogr./Géographie Can.* **2008**, *52*, 222–240. [[CrossRef](#)]
- Tang, B.; Li, L.; Lin, L.; Liu, L. Research on image perception and structure of tourists in Guangzhou Huacheng Square based on cognitive map. *Areal Res. Dev.* **2022**, *41*, 119–124+130.
- Shen, S.; Xue, L.; Liu, Y. An analysis of the deformation and factors of cognitive maps of Beijing residents based on hand-drawn sketches. *Acta Geogr. Sin.* **2008**, *06*, 625–634.
- Zhang, X.; Su, J.; Wei, S. Research on image space and its structure of urban residents in Lanzhou. *Hum. Geogr.* **2010**, *25*, 54–60.
- William, N. *Human Geography*; Oxford University Press: London, UK, 2002.
- Orleans, P. Differential cognition of urban residents: Effects of social scale on mapping. In *Image and Environment: Cognitive Mapping and Spatial Behavior*; Downs, R.M., Stea, D., Eds.; Aldine: Chicago, IL, USA, 1973; pp. 115–130.
- Domosh, M. Feminism and urban imagery. *Urban Geogr.* **1995**, *16*, 643–648. [[CrossRef](#)]
- Zhang, C.; Bai, K.; Ma, Y. A study on the cognitive sequence of destination spatial image of inbound tourists in Xi'an. *Geogr. Res.* **2014**, *33*, 1315–1334.

24. Feng, W.; Huang, G. Analysis and evaluation of urban image elements based on residents' perception in Chongqing. *Geogr. Res.* **2006**, *25*, 803–813.
25. Pacione, M. *Urban Geography: A Global Perspective*; Routledge: London, UK, 2001; pp. 389–393.
26. King, L.J.; Golledge, R.G. *Cities, Space and Behavior: The elements of Urban Geography*; Prentice-Hall: Englewood Cliffs, NJ, USA, 1978; pp. 236–256.
27. Golledge, R.G. Representing, interpreting, and using cognized environments. *Pap. Reg. Sci.* **1978**, *41*, 168–204. [[CrossRef](#)]
28. Siegel, A.W.; White, S.H. The development of spatial representations of large-scale environments. *Adv. Child Dev. Behav.* **1975**, *10*, 9–55. [[CrossRef](#)] [[PubMed](#)]
29. Tao, W.; Chen, H.; Lin, J. Spatial morphology and cognition of traditional villages in Guangzhou from a syntactic perspective. *Acta Geogr. Sin.* **2013**, *68*, 209–218.
30. Fan, J.; Wang, L. Space analysis of rural landscape images in the Pearl River Delta. *Anhui Agric. Sci.* **2010**, *38*, 1579–1582.
31. Zhao, Q. Analysis of the tourism space image picture of Huangyao Ancient Town. *J. Guangxi Univ. Natl. (Philos. Soc. Sci. Ed.)* **2017**, *39*, 76–85.
32. Tolman, E.C. Cognitive maps in rats and men. *Psychol. Rev.* **1948**, *55*, 189. [[CrossRef](#)] [[PubMed](#)]
33. Pearce, P.L. Route maps: A study of travellers' perceptions of a section of countryside. *J. Environ. Psychol.* **1981**, *1*, 141–155. [[CrossRef](#)]
34. Guy, B.S.; Curtis, W.; Crofts, J.C. Environmental learning of first-time travelers. *Ann. Tour. Res.* **1990**, *17*, 419–431. [[CrossRef](#)]
35. Young, M. Cognitive maps of nature-based tourists. *Ann. Tour. Res.* **1999**, *26*, 817–839. [[CrossRef](#)]
36. Jiang, Z.; Zhang, J.; Han, S.; Cao, J. A review of tourist cognitive map research. *Tour. Trib.* **2009**, *24*, 77–85.
37. Tang, Y.; Zhang, H. A comparative study of destination spatial image before and after tourism: A case study of Chinese tourists in South Korea. *Areal Res. Dev.* **2018**, *37*, 103–109.
38. Tian, F. Analysis on the image characteristics of urban recreation space under the background of national leisure: A case study of Nanchang City. *Resour. Sci.* **2013**, *35*, 1095–1103.
39. Kevin, L. *City Image*; Fang, Y.; He, X., Translators; Huaxia Publishing House: Beijing, China, 2001; p. 35.
40. Lee, Y.; Schmidt, C.G. Urban Spatial Cognition: A Case Study of Guangzhou, China. *Urban Geography* **1986**, *7*, 397–412. [[CrossRef](#)]
41. Lan, W.; Chen, X. Spatial representation of rural tourism places from the local perspective. *Geogr. Geo-Inf. Sci.* **2022**, *38*, 82–87.
42. Jiang, Z.; Zhang, J.; Wang, H.; Zou, W. Relative height cognition and influencing factors of small-scale environmental topography: A case study of Pukou Campus of Nanjing University. *Geogr. Res.* **2012**, *31*, 2270–2282.
43. Licorice, S.P. The Influence of campus road network pattern on spatial cognition based on anchor point theory: A case study of Peking University and Tsinghua University. *J. West. Hum. Settl.* **2019**, *35*, 88–96.
44. Khotbehsara, E.M.; Safari, H.; Askarizad, R.; Somasundaraswaran, K. Investigating the role of spatial configuration on visitors' spatial cognition in health-care spaces: Case studies in Gilan, Iran. *Facilities* **2022**, *40*, 617–637. [[CrossRef](#)]

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