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Cognitive integration or separation? Innovation-driven urban redevelopment in urban villages

Abstract: In the context of a knowledge economy and innovation-driven development, innovation districts have emerged as place-based urban development tools increasingly embedded within the urban redevelopment of old districts. While this economically and industrially oriented redevelopment pattern revitalizes urban spaces, it also raises concerns about social integration and community inclusion. This study proposes using cognitive regions as a key lens to assess whether urban redevelopment trends toward social integration or segregation, examining the cognitive coupling that occurs when innovation-driven selective redevelopment is inserted into the context of Chinese urban villages. Using Tangdong Village in Guangzhou as a case study, we apply an enhanced cognitive interview (ECI) method combined with visual and spatial analyses to identify cognitive disconnections between different groups toward original residential and innovation spaces, manifested in differences in cognitive elements, focal points, core ranges, and meaning interpretations. At the same time, the transitional streets and environmental improvements surrounding the innovation spaces are weakening the perceived boundaries between the two. We further outline the potential phased evolution of the cognitive impacts of this pattern and highlight that balancing the needs of different groups throughout this process is key to achieving inclusive and sustainable redevelopment.

Key words: Urban redevelopment; Innovation districts; Cognitive region; Informal settlements; Cognitive interview

Introduction

Urban redevelopment is one of the most significant dynamic processes in complex urban contexts. It aims to systematically renovate and redevelop old or functionally declining urban areas (Wang et al., 2022), exerting profound impacts on urban spatial patterns and socio-spatial relations (Wu & He, 2005). Existing urban redevelopment practices have increasingly developed into forms of selective redevelopment, such as the insertion of innovation spaces into old urban areas (Kayanan et al., 2022), the introduction of cultural and tourism functions (Lazzeretti & Capone, 2015), and the development of art industries and art spaces (Yang & Qian, 2024; Zhang et al., 2024). This form of redevelopment mainly involves partial reconstruction or functional replacement. It generally does not alter the rights holder or tenure of land-use rights, although it may involve partial changes in land use (Huang et al., 2020; Zeng et al., 2020).

While this model promotes mixed land use, it also entails many potential problems. Existing studies have extensively discussed, at the social level, the potential conflicts and tensions that may arise among different groups when new spaces, industries, and populations are introduced, leading to debates over gentrification and displacement (Morisson & Bevilacqua, 2019). This approach may also subtly erode local heritage, replace community identities, and overlook the future development of original residents within the community. As a result, increasing attention has been given to social inclusion, cultural preservation, and community participation in the urban redevelopment process (Tan & Altrock, 2016; Wu et al., 2022). After new functional spaces are inserted into the existing community fabric, different groups may physically share the same area, but they do not necessarily understand this space in the same way (Campbell et al., 2009).

Therefore, social integration in urban redevelopment concerns not only whether space has been transformed, functions have been mixed, or facilities have been improved, but also how different groups perceive, delineate, and attach meanings to the same redeveloped space.

In the Global South, urban redevelopment is closely associated with informal settlements (Gilbert, 2007). These settlements are typically characterized by low-quality housing and inadequate infrastructure, and their residents are often low-income groups, making such places focal points of urban governance (Wu, 2016). In China, traditional rural settlements have gradually become surrounded by built-up urban areas during the rapid urbanization process (Wang et al., 2009), giving rise to the phenomenon of urban villages, a typical form of informal settlement. With the rise of stock-oriented urban redevelopment, urban villages have become key areas of focus in the redevelopment of China's megacities (Jiang et al., 2020) and represent some of the most important and complex spaces within old urban districts (Guo et al., 2017).

In recent years, innovation districts have gained increasing attention as place-based urban development strategies (Pancholi et al., 2015; Yigitcanlar, 2014). In China, urban villages have begun to develop an innovation-driven form of selective redevelopment. This approach transforms village-level industrial parks by introducing incubators and maker-space clusters, accompanied by supporting residential and commercial facilities, while retaining the original residential areas of the urban village. As a result, a striking contrast emerges between the residential and innovation spaces within the same area. Functionally, the core of urban villages lies in housing and low-cost living (Wu & Wang, 2016), whereas innovation spaces emphasize industrial and economic functions, generating tensions between living and production. In terms of spatial quality, urban villages are often perceived as low-quality spaces that are "in the city, but not of the city" (Buckingham & Chan, 2018), even described as "isolated islands" (Chung, 2010) or "scars of the city" (Al, 2014). In contrast, the success of innovation spaces depends on high-quality environments that enhance talent attraction (Esmaeilpoorarabi et al., 2018a). Regarding social structure, urban villages are mainly inhabited by low-income, long-term local residents (Wu, 2016), while innovation spaces attract highly educated and mobile innovation workers. The sharp differences between the two groups may exacerbate social segregation (Gao & Lim, 2023), and spatial transformation can also reshape the identity of original residents (Li et al., 2016). In terms of governance logic, the existence of urban villages originates from historical land systems and grassroots autonomy (Wu, 2016), whereas the development of innovation spaces reflects the combined influence of national strategies, market capital, and local pilot initiatives, leading to governance tensions between private market efficiency and community public participation (Rubin, 1988).

It is evident that the stark contrast between urban villages as informal settlements and innovation spaces makes innovation-driven urban redevelopment a complex and noteworthy form of redevelopment practice. Beyond governance and economic dimensions, embedding new functional urban spaces into urban villages also constitutes a process of cognitive collision (Zhao et al., 2021). This process involves not only how people perceive and evaluate the spatial and functional distinctions between old and new areas, but also how different groups construct meanings and social identities through their use, understanding, and sense of belonging to space. In dynamic spatial contexts, people's re-understanding and cognitive adaptation to spatial relationships are crucial for enhancing the usability of the existing built environment (Montello & Raubal, 2012). However, the cognitive impacts of community redevelopment have received limited scholarly attention. Furthermore, cognitive differences among different groups regarding the same community may represent an important source of bias in studies of neighborhood effects (Coulton et al., 2001). **Focusing on such cases, this study investigates how cognitive differences emerge among different groups toward the same area in the process of innovation-driven urban redevelopment.** From the perspective of social cognitive integration, the study aims to identify strategies that facilitate positive interactions in selective redevelopment, thereby promoting more

82 inclusive urban redevelopment.

83 **Literature review**

84 *Innovation-driven urban redevelopment and social (dis)integration*

85 In the era of the knowledge economy, cities have widely pursued knowledge-based urban development
86 (KBUD), which integrates research, technology, and human capital to promote economic prosperity and
87 enhance competitiveness (Benneworth & Ratinho, 2014; Carrillo, 2004). The concept of innovation districts
88 emerged in this context as a policy response to the spatialization of the knowledge economy (Carrillo et al.,
89 2014). Innovation districts are urban areas where anchor institutions, startups, and incubators cluster together
90 (Bruce & Julie, 2014). These areas are characterized by compact spatial forms, convenient transportation,
91 mixed-use functions, and advanced infrastructure (Drucker & Kayanan, 2024), offering knowledge workers
92 integrated environments for working, living, learning, and recreation (Pancholi et al., 2019).

93 *Innovation-driven urban redevelopment refers to the formation of innovation districts through the*
94 *redevelopment of old industrial areas, former ports, or declining urban areas (Bruce & Julie, 2014), and is*
95 *closely connected to urban cores (Morisson & Bevilacqua, 2019).* These districts emphasize openness and
96 hybridity, taking advantage of existing infrastructure and the diversity of urban life (Hawken & Hoon Han,
97 2017) to revitalize declining urban areas and address mismatches between employment and housing
98 (Esmailpoorarabi et al., 2020b). At the same time, they focus on integrating with surrounding communities,
99 sharing affordable public facilities and accessible resources to enhance overall urban sustainability and social
100 inclusion (Charnock & Ribera-Fumaz, 2011; Esmailpoorarabi et al., 2018b).

101 As a policy convergence between knowledge-based urban development and urban redevelopment,
102 innovation districts are expected to diversify community socioeconomic structures, reduce class segregation,
103 and expand residents' opportunity networks (Joseph et al., 2007). However, they also generate tensions for
104 residents most affected by upcoming redevelopment (Kayanan et al., 2022). Existing studies have shown that
105 innovation districts may reproduce spatial inequalities typical of earlier urban development projects. The
106 factors that attract knowledge-economy firms and talent often conflict with the preferences of ordinary
107 residents (Florida, 2002). When real estate development interests dominate, high-end housing and premium
108 amenities are prioritized, while affordable housing and public services are deprioritized (Laskey & Nicholls,
109 2019). Rising housing prices and rents may undermine long-term community goals and even force residents
110 and service workers to relocate (Kayanan et al., 2022). Service workers who perform essential tasks such as
111 cleaning, maintenance, and food service are crucial to the operation of innovation districts but are often
112 marginalized, with increasingly precarious living conditions (Kayanan et al., 2022; Mallach, 2015). Thus,
113 while innovation districts bring economic vitality, they may also intensify gentrification and social
114 polarization (Morisson & Bevilacqua, 2019). Scholars have therefore emphasized that social integration,
115 multi-group interaction, and benefit coordination should become central goals in the planning and governance
116 of innovation districts to achieve more inclusive and sustainable development (Gao & Lim, 2023; Pancholi et
117 al., 2018).

118 *Scholars have therefore emphasized that social integration, multi-group interaction, and benefit*
119 *coordination should become core goals of innovation-driven redevelopment and governance in order to*
120 *achieve more inclusive and sustainable development (Gao & Lim, 2023; Pancholi et al., 2018). Differences in*
121 *income, identity, and lifestyle between residents and newly arrived innovation groups make this process of*
122 *spatial embedding highly uncertain. At the cognitive level, most people still perceive innovation districts*

primarily as places for work and study, while giving less recognition to their living and leisure functions; cognitive differences among groups are therefore particularly evident (Esmaeilpoorarabi et al., 2020b).

The success of innovation-driven redevelopment depends not only on physical construction and economic logic, but also on cognitive integration among residents, users, and organizations (Davis & Wagner, 2024). When different groups hold divergent understandings, values, and uses of the same space, ignoring such cognitive differences can easily deepen social division. Therefore, understanding how different groups perceive, interpret, and respond to spatial transformation, and how cognitive differences may be reconciled in this process, can help reduce exclusionary effects in planning and governance and prevent a one-dimensional logic of gentrification.

Geographic cognitive regions as lenses on cognitive integration

In geographical research, cognitive regions (also known as perceptual regions) are spatial units constructed through people's perceptions, experiences, and cultural interpretations (Montello et al., 2014). They differ from administrative or functional regions, which are defined by formal boundaries or patterns of interaction, as cognitive regions are determined by how people collectively imagine and understand space (Montello et al., 2003). One of the important characteristics of cognitive regions is their fuzzy boundaries and flexible membership functions (Montello et al., 2014). This vagueness does not imply randomness; rather, it reflects how people simplify complex environments into general rules and categories (Bae & Montello, 2018). Even when individuals maintain coherent mental models of large-scale spatial relations in familiar environments, these representations generally fail to support precise metric judgments (Tversky, 1993). While people may diverge in their judgments of peripheral areas, they often converge on a shared core, revealing both the subjectivity and the social consensus inherent in vague regions (Xiao, 2025).

This vagueness also arises from individual differences. People do not necessarily agree on the precise extent of a region, and their boundaries may diverge according to personal experience, cultural background, or social identity (Bae & Montello, 2018). For example, residents may define the limits of the same neighborhood differently depending on where they live within it, how they use local facilities, or which social networks they engage in (Campbell et al., 2009). Cognitive regions are also dynamic, adapting to changing environments. People conceptualize their cognitive regions in different ways, adjusting boundaries in response to varying contexts, purposes, or temporal conditions (Coulton et al., 2001). The cognitive plate tectonics hypothesis proposes that people organize a region around a key reference point, and when this point shifts, other locations within the region adjust accordingly, as if the entire region moves like a tectonic plate (Couclelis et al., 1987).

Cognitive regions may also shift over longer periods as the built environment changes (Campbell et al., 2009). The degree of consensus that different groups hold about neighborhood boundaries or extents depends on the extent to which they share the physical and social characteristics of the neighborhood (Chaskin, 1997). The possibility of such differences highlights the flexibility and diversity of cognitive regions: in different contexts, people may cognitively adapt by shifting perceived boundaries and reinterpreting place meanings (Campbell et al., 2009; Lee & Campbell, 1997).

This dynamic quality makes cognitive regions particularly useful for understanding urban redevelopment. Existing studies on urban redevelopment and social integration have primarily focused on dimensions such as land-use change, housing affordability, governance arrangements, and community participation. These studies are important for explaining how redevelopment reorganizes space and resources, but they do not fully account for how different groups mentally reorganize a changing place, redraw perceived boundaries, or assign different place meanings to newly inserted spaces. In other words, physical proximity, infrastructure

improvement, or functional mixing does not necessarily mean that different groups cognitively understand the redeveloped area as a shared place. Tracing the dynamic evolution of cognitive regions can not only reveal how groups adapt to spatial transformation, but also help scholars and policymakers assess whether redevelopment is moving toward integration or exclusion, providing a distinctive theoretical and methodological basis for evaluating the social effects and long-term sustainability of urban redevelopment.

Methodology

Study area

Chinese urban villages have become important sites for innovation-driven redevelopment. Through governance restructuring and land transformation, they enable the renewal of informal spaces and demonstrate a distinctive localized practice of this broader global trend. Urban village redevelopment has gradually become aligned with higher-level innovation policies, giving rise to “micro innovation districts” that differ from large-scale city-level innovation districts. These spaces often rely on the redevelopment of village-level industrial parks, developing networks of maker spaces and incubators that support grassroots innovation and the growth of small and micro enterprises. The locational advantages, low land rents, and abundant living amenities of urban villages provide fertile ground for innovative activities, while their original residential spaces offer daily support systems for innovation spaces, including low-cost housing, dining, and service facilities.

Since 2017, the Guangzhou municipal government has integrated the promotion of innovation and entrepreneurship with the redevelopment of urban villages, forming micro innovation districts within these areas. This approach aims to revitalize existing resources while simultaneously generating tax revenue, creating jobs, and promoting industrial transformation and technological advancement. By 2020, Guangzhou had established 166 incubators and 87 maker spaces through the redevelopment of collectively owned village properties, with a total incubation area exceeding 10 million square meters and more than 11,000 enterprises and projects under incubation. This model advances the redevelopment of industrial parks through a government-guided, market-operated, and co-built and shared approach. Professional and market-oriented organizations are introduced to manage operations. Typically, operators lease entire properties from the ownership entities and are responsible for key management tasks, including the positioning, planning, renovation, and operational services of the innovation districts.

Tangdong Village is a typical example of how Guangzhou has transformed urban villages into micro innovation districts. In 2015, with government support and guidance, Tangdong Village partnered with a listed company to upgrade and renovate its old factory buildings, establishing a business incubation base that has since attracted a number of high-tech enterprises with strong innovation capacity. Figure 1 illustrates the location of Tangdong Village, with the basemap provided by the Standard Map Service System of the Ministry of Natural Resources of China and Maxar’s high-resolution imagery basemap products. We also retrieved the point-of-interest (POI) data of companies in Tianhe District, Guangzhou, for the years 2014 and 2024 from the Amap application programming interface (<https://lbs.amap.com>). The data clearly show an increase in the number of enterprises within the village over time. The insertion of innovation spaces in Tangdong Village did not displace the locations of the original residential areas. The residential spaces remain concentrated in the northwest, while the innovation spaces are primarily located in the southeast, exhibiting distinct differences in both density and spatial mechanism.

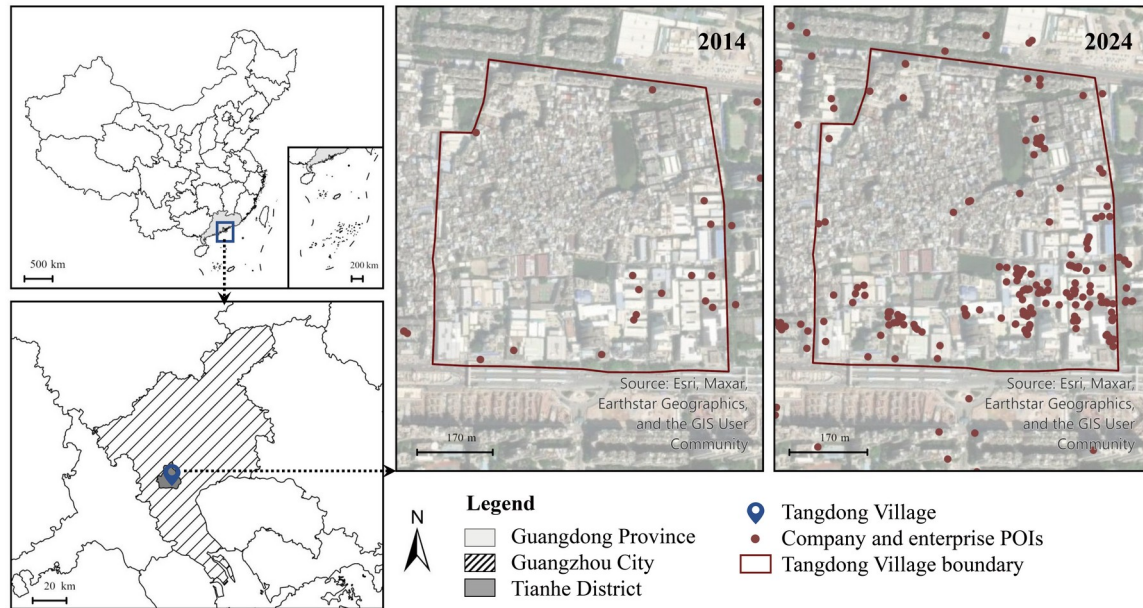


Figure 1. Map of Tangdong Village.

Analytical framework

Urban planning should engage with broader collective cognition and move toward cognitive integration (Candeloro et al., 2024). Accordingly, this study proposes a new perspective: the similarity of cognitive regions during dynamic adaptation can serve as a new clue for assessing whether urban redevelopment promotes social integration. From the perspective of cognitive regions, this study combines enhanced cognitive interview (ECI), visual analysis, and spatial analysis to examine the cognitive regions of different groups from multiple dimensions (Table 1).

Table 1. Analytical framework of cognitive regions.

Analytical dimension	Data source	Analytical indicator	Theoretical meaning
Spatial attentional focus	Self-directed photography; visual content analysis	Photo themes; visual elements	Identifies which spaces and elements are cognitively salient to different groups
Location of cognitive cores	Spatial analysis of photo locations	Mean center	Indicates whether the cognitive cores of different groups are displaced, separated, or moving closer to each other
Range and orientation of cognitive regions	Spatial analysis of photo locations	Standard deviational ellipse	Shows the spatial extent, dispersion, directionality, and overlap of group-specific cognitive regions
Place meanings	Enhanced cognitive interview (ECI)	Participants' interpretations of photos, spaces, and spatial changes	Reveals how different groups assign meanings to original residential spaces, innovation spaces, and Tangdong Village as a whole
Perceived boundaries	Enhanced cognitive	Descriptions of boundaries,	Indicates whether original residential

interview (ECI); photos of transition areas	transition areas, environmental improvements, and spatial continuity	spaces and newly inserted innovation spaces are perceived as separate, connected, or partially integrated
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Enhanced cognitive interview combined with self-directed photography

The Cognitive Interview (CI) is an interviewing technique developed by psychologists, widely regarded as the most effective method for enhancing the quantity and quality of elements recalled by participants (Nori et al., 2014). CI emphasizes the reconstruction of context during the interview as a participant-centered interview process (Ginet et al., 2019). Enhanced Cognitive Interview (ECI), an evolved version of CI, is more effective in capturing a greater amount of human cognitive information (Paulo et al., 2016a, 2016b). ECI encourages interviewers to transfer control to the interviewee, emphasizing open-ended questions and the use of guided imagery during questioning (Fisher et al., 1987).

Imagery used in ECI can elicit more detailed information about actions and environmental aspects (Nori et al., 2018). Cognitive processes at an environmental scale require locomotion to capture all dimensions (Montello, 1993). In spatial research, visual expression often conveys a subject's feelings, emotions, and various psychological states more effectively (Rose, 2014). By using self-directed photography, collecting photographs taken by individuals as they move through their environment, and using these photos as stimuli to extract information and related data from participants, we can better understand how participants perceive space (Zhang et al., 2023). Therefore, we combined self-directed photography with ECI, allowing participants to actively take photos of their environments and describe their motivations for doing so, thereby shifting the control of the interview to the participants. This approach not only captures more detailed information about behaviors and environments but also reveals people's cognitive structures and attentional characteristics within specific spatial contexts. For this reason, it is adopted in this study as a method for investigating cognitive regions.

This study selected three groups of participants to compare their different spatial relationships with and experiences of Tangdong Village. The first group consisted of original residents, namely native villagers who had lived in Tangdong Village for a long period and maintained sustained connections with local everyday life, community relations, and village memory. Temporary tenants and migrant renters were not included in this group in order to avoid conflating spatial cognition shaped by different lengths of residence and forms of place attachment. The second group consisted of innovation workers, namely people who worked daily in the newly inserted innovation spaces or used related office facilities, including park managers and regular workers. This group was selected to reflect how users of the newly inserted spaces perceived Tangdong Village. The third group consisted of university students, who served as the external group in this study. They were included to examine how people who were not deeply embedded in the village's residential or working networks understood the juxtaposition of old and new spaces, environmental transformation, and the image of Tangdong Village.

The fieldwork was conducted from June to October 2023. We recruited 10 residents of Tangdong Village, 10 staff members from the innovation spaces, and 10 university students to participate in the ECI combined with self-directed photography. Residents and staff members were recruited with the assistance of the village committee and the management team of the innovation spaces, while university students volunteered through campus announcements. The participants maintained a balanced gender ratio, and their demographic information is presented in Table 2.

Table 2. Demographics of participants.

Original residents			Innovation workers			External group (University students)		
ID	Sex	Age	ID	Sex	Age	ID	Sex	Age
A1	Male	61-70	B1	Male	21-30	C1	Male	18-25
A2	Male	61-70	B2	Male	21-30	C2	Male	18-25
A3	Male	51-60	B3	Male	31-40	C3	Male	18-25
A4	Male	41-50	B4	Male	21-30	C4	Male	18-25
A5	Male	31-40	B5	Male	31-40	C5	Male	18-25
A6	Female	51-60	B6	Female	31-40	C6	Female	18-25
A7	Female	41-50	B7	Female	21-30	C7	Female	18-25
A8	Female	31-40	B8	Female	31-40	C8	Female	18-25
A9	Female	41-50	B9	Female	21-30	C9	Female	18-25
A10	Female	41-50	B10	Female	31-40	C10	Female	18-25

Following the ECI process outlined in previous studies (Fisher & Geiselman, 1992; Ryan et al., 2020), we combined the ECI process with the method of self-directed photography, dividing the survey into seven stages (Table 3). In the self-directed photography section, participants were asked to take photos within the boundaries of Tangdong Village. They were instructed to capture places they found meaningful or characteristic for the village, with each participant contributing 10 photographs, totaling 300 images. The guiding questions primarily focused on their perceptions of the original residential spaces of the urban village and the newly inserted innovation spaces. Key questions were directed at the photos that stood out to them, exploring specific visual elements, the underlying reasons, interactions between different subjects, and their views on changes in the Tangdong Village environment.

Analysis of self-directed photography photos

After collecting the self-directed photographs, we conducted a detailed analysis. The first step was visual content analysis, which involved deconstructing, coding, and categorizing visual elements to understand the meanings that visual producers of different attributes intended to convey (Rose, 2011). All photographic materials were imported into NVivo 14 for qualitative coding. The coding process consisted of two stages: the first stage was main theme coding, in which photos were categorized according to the spatial attributes of Tangdong Village, including innovation space, original residential space, transition area between the two, and village periphery; the second stage was subtheme coding, in which the specific visual elements within each photo, such as building facades, street scenes, signs, and public spaces, were identified to reveal participants' focal points within the environment (See Appendix A for details). To ensure comparability across photographs, each photograph was assigned only one main theme and one subtheme. When multiple visual elements appeared in the same photograph, the coding decision was based on the primary photographed object, the central composition of the image, and the participant's explanation of the motivation for taking the photograph during the interview. To enhance transparency and reliability, two researchers independently conducted the initial coding, then compared and discussed discrepancies to reach consensus and establish a unified coding framework. Coding consistency was assessed using Cohen's Kappa coefficient, and the results indicated high agreement at the main theme level ($k > 0.8$).

Building on the visual content analysis, we further analyzed the geographic locations of the photographs. The photo points were visualized in ArcGIS Pro based on their geographic coordinates. To characterize the

cognitive region features of different groups, we calculated each group's mean center and standard deviation ellipse. The mean center indicates the spatial focus of visual attention, while the standard deviation ellipse (at a one-standard-deviation range) reflects the spatial dispersion and directionality of cognitive activity. The area of the ellipse represents the breadth of the cognitive core region, and the orientations of its axes indicate the direction of spatial cognitive extension. By comparing the displacements of mean centers and the ranges of ellipses across the three groups, we were able to identify cognitive regional differences among social groups within Tangdong Village.

Table 3. ECI process combined with self-directed photography.

Phases	Process	Guiding questions for the participants
1) Establish rapport	Establish a preliminary relationship with participants	a. Participant's basic information b. Participant's understanding of Tangdong Village
2) Transfer control	Allow participants to begin self-directed photography, capturing impressions of Tangdong Village through a walk-and-shoot method	-
3) Focused retrieval and report everything using photos	Encourage participants to focus on their photos, recalling and reporting relevant spatial elements and motivations for taking each photo, regardless of perceived relevance	a. (Reviewing each photo) What was the motivation behind each photo taken? b. Which photos left the deepest impression or which visual elements were of most interest? Why? c. What aspects of Tangdong Village make it appealing for living or working? Why?
4) Mental reinstatement of context	Guide participants to mentally recall detailed aspects of Tangdong Village, including sensory experiences, emotions, and feelings	a. How do you perceive Tangdong Village as a space? b. (Reviewing each photo) What are your feelings and emotions towards the related spatial elements?
5) Interviewee compatible questioning	Ask targeted questions based on participants' identities	Original residents: a. How has the innovation spaces impacted your living experience? b. Do you interact with innovation workers? Innovation workers: a. Why did you choose to engage in entrepreneurship in Tangdong Village? Do you find that innovation spaces based on village foundations are conducive to entrepreneurship? b. Do you interact with residents? University students: How does your perception of Tangdong Village as a living and innovation space align or differ from your expectations?
6) Varied retrieval	Instruct participants to shift their perspective and describe the space from another viewpoint	Original residents: a. Would you choose to work in the village? b. What would be your ideal innovation space? Innovation workers:

Phases	Process	Guiding questions for the participants
		a. Would you consider living in Tangdong Village? b. What would be your ideal living space in the village? University students: a. Would you consider living or working in Tangdong Village? b. What would be your ideal living or innovation space in the village?
7) Summary, closure, and evaluation phase	Summarize, organize, and integrate the information collected throughout the interview	a. How do you view the insertion of innovation spaces in Tangdong Village? b. (After reviewing the photos of all participants) Which photo do you think best represents Tangdong Village and its different types of spaces?

Empirical patterns of cognitive regions in Tangdong Village

Differences in cognitive elements and foci across social groups

Based on the categorization of self-directed photographs (Table 4), the cognitive elements of Tangdong Village perceived by original residents, innovation workers, and the external group (university students) show clear differences. Both original residents and innovation workers focus primarily on the areas where they live or work. Most of the residents' photos were taken within the original residential areas of Tangdong Village, while about three-quarters of the photos taken by innovation workers came from innovation spaces, indicating a rather fragmented overall perception of the village. In addition, innovation workers appeared to pay more attention to peripheral facilities than the original residents did. By photographing surrounding transport infrastructure and nearby commercial housing, they highlighted Tangdong Village's locational advantage in balancing work and life. In contrast, university students showed a more balanced focus across different spatial types. As they were not part of any specific space within Tangdong Village, they viewed the area from a more holistic perspective. Beyond the spaces emphasized by residents and innovation workers, they were particularly interested in the transitional zones between the innovation and residential spaces, which displayed a complex assemblage of new and old spaces and elements:

There are some very special places where the glass walls of the innovation-space buildings happen to reflect the shadows of the old village houses. When you work here and look outside, you see the people who still live in the village; and when those living in the village look out, what they see are the workplaces. The whole scene feels quite subtle. (Participant C4)

In terms of the understanding of representative visual elements, we examined different groups' main impressions of Tangdong Village and its original residential and innovation spaces through the ECI (Figure 2). These impressions were derived from the spatial photos that participants selected from all their photographs as the most representative of Tangdong Village. We identified the photos most frequently chosen for each spatial category and visualized their geographic locations to reveal differences in cognitive focus and meaning construction among the groups. The results show that the meanings of Tangdong Village were interpreted in distinctly divided ways across the different groups.

In the original residential space, the representative photo chosen by original residents depicted traditional places such as ancestral halls (Figure 2a), reflecting their continued attachment to local memory and

community relations. The representative image selected by external participants and innovation workers focused more on narrow alleyways and ground-level commercial activities (Figure 2b-c), revealing stereotypical perceptions of the urban village. Within the innovation space, original residents tended to view it from an external perspective as a symbol of modernization (Figure 2d), maintaining a clear distance from their own living world. On the other hand, university students selected representative image showing open, shared, and socially oriented interior scenes of innovation spaces (Figure 2e), demonstrating their interest in the atmosphere of emerging spaces. The representative image selected by innovation workers mainly showed peripheral roads and commuting routes (Figure 2f), indicating their focus on accessibility and spatial efficiency. At the level of overall impressions, original residents regarded the village archway and main street as the core symbols of Tangdong Village (Figure 2g), emphasizing community continuity and place identity. University students' image highlighted the juxtaposition and contrast between old and new buildings (Figure 2h), showing a more integrative understanding of the transforming landscape. Innovation workers perceived Tangdong Village as a convenient area for both work and living, focusing mainly on its advantageous transport location (Figure 2i).

Table 4. Content analysis of self-directed photography.

Participants	Main themes	Subthemes	Proportion of photos
Original residents	Innovation spaces	Public spaces	2%
		Building facades	7%
		Signage	5%
		Street scenes	9%
	Original residential spaces	Public spaces	21%
		Building facades	12%
		Ground-level commercial services	24%
		Street scenes	18%
	Transition areas	Transition areas between innovation spaces and residential spaces	0%
	Peripheries	Transportation facilities	2%
		Other residences	0%
Innovation workers	Innovation spaces	Public spaces	48%
		Building facades	12%
		Signage	9%
		Street scenes	7%
	Original residential spaces	Public spaces	0%
		Building facades	2%
		Ground-level commercial services	10%
		Street scenes	2%
	Transition areas	Transition areas between innovation spaces and residential spaces	0%
	Peripheries	Transportation facilities	7%
		Other residences	3%
External group (University)	Innovation spaces	Public spaces	7%
		Building facades	17%

Participants	Main themes	Subthemes	Proportion of photos
students)		Signage	18%
		Street scenes	10%
	Original residential spaces	Public spaces	3%
		Building facades	6%
		Ground-level commercial services	12%
		Street scenes	12%
	Transition areas	Transition areas between innovation spaces and residential spaces	5%
	Peripheries	Transportation facilities	6%
		Other residences	4%

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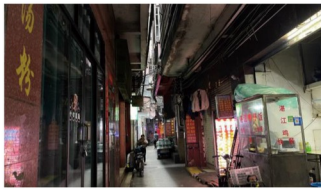
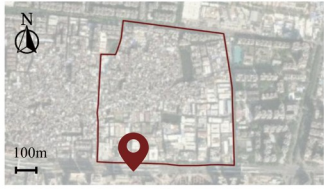
	Original residents	University students	Innovation workers
Impression of original residential space			
			
	a. Ancestor halls and other traditional public spaces in Tangdong Village	b. Narrow alleys and vibrant ground-level commercial spaces	c. Narrow alleys and dilapidated buildings
Impression of innovation space			
			
	d. High-end, independently managed office buildings	e. Public and office spaces conducive to innovation and communication	f. Well-maintained external environments and highly accessible living spaces
Overall impression of Tangdong Village			
			
	g. Main street marked by Tangdong Village's historical archway	h. A combination and collision of diverse elements	i. Convenient transportation locations and a rich rental housing market

Figure 2. Main impressions of Tangdong Village and its original residential and innovation spaces.

Segregation of cognitive regions and the weakening sense of boundaries

Figure 3 shows the spatial distribution of the photo locations for the three participant groups, along with their mean centers and standard deviation ellipses, which represent the core range and central position of their cognitive regions. The photo points of original residents were mainly concentrated in the northwestern part of the village, corresponding to the original residential space. Their cognitive region covered a relatively large area and showed an axis-oriented extension from southwest to northeast, indicating a strong familiarity with and social connection to the residential environment. In contrast, the photo points of innovation workers were clearly concentrated in the southeastern innovation space, with a more compact standard deviation ellipse, suggesting that their cognitive activity was focused on the innovation area and its immediate surroundings. The university students' photo points were more dispersed, and their cognitive center was located between the other two groups, reflecting their dual focus on both residential and innovation spaces during their exploration. Overall, the three groups' standard deviation ellipses displayed a spatial shift in cognitive centers from northwest to southeast, revealing the cognitive separation between the residential and innovation spaces.

This spatial separation was further reflected in participants' verbal descriptions. Each group tended to refer to only the residential areas that matched the stereotypical image of an urban village as "the urban village," while describing the innovation spaces with other terms such as "entrepreneurship park" or "industrial park." For innovation workers, the urban village was perceived mainly as a low-cost resource hub rather than a place of emotional belonging. They did not actively integrate into the existing community networks, and in their perception, the urban village still represented narrow streets and dilapidated buildings. A similar understanding appeared among the external group. University students viewed the original residential areas and innovation spaces as two distinctly separate zones that were difficult to connect. In their imagination, the daily life, architectural style, and resident population of the urban village could hardly mix with innovation activities. They considered the innovation spaces to be relatively high-end, clean, and aligned with an intellectual aesthetic, whereas the urban village was seen as a setting of vernacular, everyday culture. The two spaces, therefore, remained symbolically divided in their cognitions.

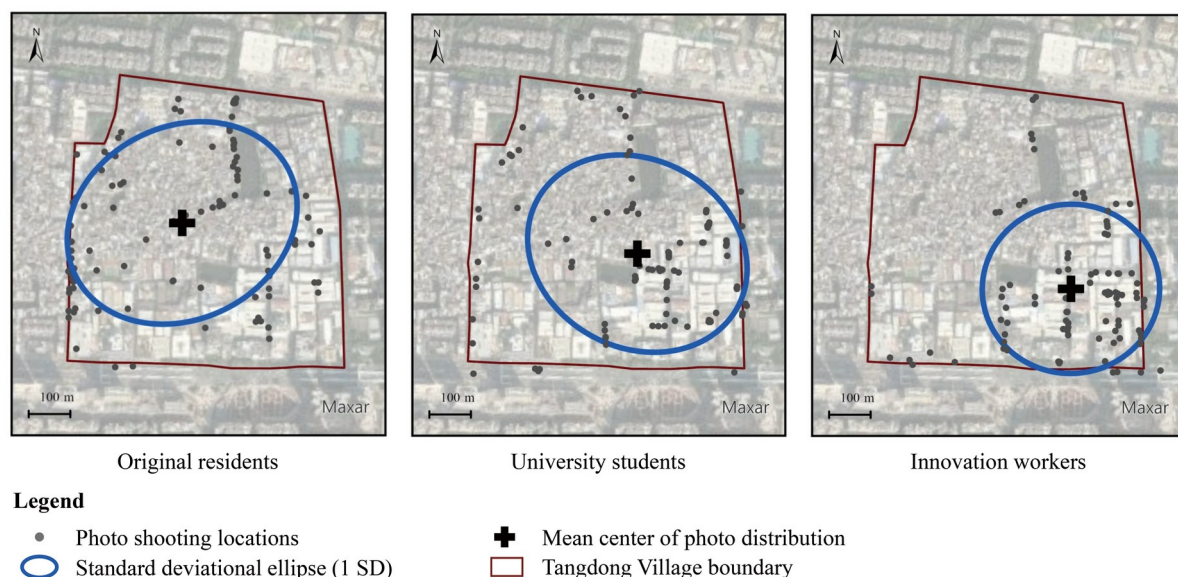


Figure 3. Photo distribution, mean centers, and standard deviational ellipses.

Differences in the cognitive core regions stem from the separation of different groups in their living circles, social networks, and daily activities. The temporal rhythms of these groups, that is, the nature of their repeated interactions with space, play a central role in shaping the relationships between spatial use, facilities, and spatial perception (Westerholt et al., 2022). For innovation workers, the proximity of Tangdong Village and the surrounding areas offers relatively low housing rents and living costs. Innovation spaces located within the village provide convenient access to everyday needs such as food and services, so they do not rely on the lower-standard housing traditionally associated with the urban village. For original residents, however, most innovation spaces function as independent compounds, often with gated access, creating physical barriers that limit encounters with innovation workers in everyday life. Residents continue to spend time in traditional public spaces such as ancestral halls, which innovation workers rarely visit. The original residents maintain a strong attachment to their community and a culture of frequent neighborhood interaction. This persistence is supported by a long-standing collective economy and closed kinship- and locality-based social networks, which differ from those found in other types of Chinese communities (Hazelzet & Wissink, 2012; Liu et al., 2017). In the self-directed photographs, innovation workers frequently captured images of shared activity spaces within enterprises, focusing on the atmosphere and functional features of the innovation spaces. This reflects that most of their everyday interactions occur within their workplaces rather than with the local community.

Despite the lack of cognitive integration, participants generally believed that the innovation spaces and the original residential areas can currently coexist as parallel spaces where both old and new groups benefit. Start-up companies have gained access to affordable office and entrepreneurial spaces, while innovation workers enjoy convenient environments for both work and daily life. The village committee restructured to establish the Tangdong Village Economic Development Corporation, allowing shareholders to receive rental dividends, and some villagers have taken up logistical or service positions related to the innovation spaces. Moreover, participants across different groups perceived that the introduction of innovation spaces is helping the original urban village integrate with the surrounding city. The presence of innovation spaces has attracted the establishment of new supporting facilities in the vicinity, such as bus stops, subway stations, and commercial plazas. These developments have further stimulated local economic growth and reshaped the daily living patterns of the urban village.

Transportation has become much more convenient. There used to be no bus service, and people had to walk to Zhongshan Third Road to take a bus. Now there is both a metro line and a BRT system, so you can go directly from the entrance. The commercial area is expanding, and there are more shopping malls around, with a much greater variety of food options. The people working in the innovation and entrepreneurship spaces definitely stimulate local consumption. (Participant A7)

Although the innovation spaces and the original residential areas are still perceived as two separate communities and social groups, the sense of boundary between them is gradually weakening. The demands of innovation and entrepreneurial groups for better office environments and living facilities are progressively driving the physical reshaping of the urban village and promoting a softer spatial transition. While innovation spaces exist as relatively independent compounds, they have also produced ripple effects on the renewal of surrounding old spaces. During the development of the innovation spaces, the village committee and contracted property companies have placed particular emphasis on improving the public environment around industrial parks. They have coordinated with functional departments to upgrade infrastructure such as water supply, transportation, waste management, and sewage systems, creating better conditions for industrial transformation. The presence of innovation spaces has also stimulated the transformation of collective village

properties, reducing fire hazards and improving public security. This phenomenon is especially visible in the transitional zones between the innovation spaces and the original urban village, where the effects of urban redevelopment have extended into the connecting streets, leading to noticeable environmental improvements:

There is also an effect on the middle streets. After the innovation spaces moved in, the environment of the street that connects to the original residential area of the urban village was improved. So, in the past, this area felt more like an “urban village,” but now it has become more modern and more “urban.” (Participant B2)

Linking spatial organization and cognitive adaptation

To further understand the coexistence of separated cognitive cores and boundary softening in the Tangdong Village case, this section interprets the empirical findings in relation to the spatial organization of innovation districts and the diffusion of urban redevelopment effects. Hanna’s (2016) classification of the evolutionary patterns of innovation districts provides a spatial-organizational reference for analyzing the relationship between innovation districts and their surrounding urban environments. In this classification, the enclosed spatial model refers to a contiguous and independent area with limited integration with its surroundings, weak external accessibility of its internal circulation system, and a relatively closed functional structure. The clustered spatial model is characterized by the concentration of innovation institutions within a certain area, divided into several smaller blocks by roads, while still remaining relatively separated from surrounding buildings. The embedded spatial model integrates innovation functions organically into the everyday urban fabric, supported by well-developed surrounding infrastructure, and exhibits the highest level of spatial openness and functional interaction.

The spatial organization of innovation districts does not directly determine cognitive outcomes. Rather, it influences the cognitive regions of different groups through the spatial diffusion of urban redevelopment effects. Building on Hanna’s (2016) discussion of the spatial organization of innovation districts, and in light of the phenomena observed in Tangdong Village, this study understands cognitive adaptation in innovation-driven redevelopment of urban villages as a possible phased process. The three columns in Figure 4 correspond to the spatial organization of innovation districts, the spatial extent of redevelopment diffusion, and the state of cognitive adaptation, respectively. The left column shows the organizational transition of innovation districts from enclosed to clustered and embedded forms. The middle column shows how redevelopment effects extend from within innovation spaces to surrounding transition areas and original residential spaces. The right column shows changes in how different groups cognitively relate old and new spaces.

In the first stage, innovation districts are usually transformed from existing village-level industrial parks into enclosed and independent compounds that are physically separated from the main body of the urban village, managed independently, and socially disconnected. This stage reflects the dominance of policy and land development logic, as idle spaces are converted into productive areas that generate economic output. At this point, innovation spaces and the original residential areas remain cognitively divided. The second stage marks a strengthening of governance logic. As environmental improvements, infrastructure upgrades, and public space renovations take place around the innovation compounds, the external boundaries of the innovation areas gradually loosen, forming functional clusters centered on innovation spaces. The effects of redevelopment extend to the surrounding streets, making the transitional spaces physically and cognitively closer to the urban core, showing signs of partial integration. In the third stage, innovation spaces become fully connected with the urban system. Living and working spaces intertwine, and the increase in employment

opportunities and rental demand drives the overall renewal of the original residential areas. This phase is largely driven by market mechanisms, where population influx and rising rents promote reinvestment while also introducing potential risks of gentrification. At the cognitive level, the urban village gradually becomes part of the city's innovation network, the distinction between “inside” and “outside” weakens, and a higher level of spatial and social integration emerges.

The urban redevelopment model of Tangdong Village currently appears to be between the first and second stages. In terms of spatial form, although the innovation spaces still maintain the management structure and relatively enclosed boundaries of independent compounds, their surrounding environments have undergone gradual improvement and redevelopment. The renovation of nearby streets, transportation, and infrastructure has resulted in greater connectivity and openness. At the cognitive level, this stage presents a partially integrated mental landscape. Different groups still tend to view the innovation spaces as modern symbols distinct from the original residential areas, yet in the transitional zones, the sense of boundary is weakening. People have begun to recognize the overall environmental improvement and spatial order of the urban village. The stereotypical perceptions of the original residential spaces have not diminished this positive cognition; rather, they have been reframed as part of a gradual process of integration into the broader urban structure. As an incubation model embedded in the urban village, this approach provides policy and cost advantages for start-ups and is regarded by university students as a promising entrepreneurial path. They believe that Guangzhou's urban environment and the inclusiveness of its urban villages offer fertile ground for emerging internet enterprises. Compared with large corporations, numerous small and medium-sized innovative actors are equally vital for maintaining urban operations and generating employment. Consequently, these innovation spaces are seen not only as meeting the practical needs of entrepreneurial groups but also as effective means to enhance the city's economic vitality and inclusiveness.

However, if development enters the third stage, Tangdong Village will also face potential gentrification pressures. As the innovation spaces continue to enhance the area's value, rents and living costs may gradually rise, and the short-term vitality they bring could, over time, evolve into risks of social stratification and spatial exclusion (Kayanan, 2022). Most innovation workers are attracted to the urban village primarily because of its affordability, viewing it as a foothold for young people pursuing their dreams. Therefore, policy design needs to remain adaptive and sensitive to the complex interplay of cultural, social, and economic forces within redevelopment projects, exploring mechanisms for long-term sustainability (Tan, 2024). Maintaining spatial diversity is always important, and it is essential to ensure that newly introduced commercial and service facilities meet the needs of new groups while also accommodating the consumption capacity and habits of original residents. From the perspective of spatial organization, the small-plot, dispersed layouts commonly adopted in innovation districts improve flexibility but often lead to functional fragmentation that geographically separates different knowledge-based industries, thereby hindering cross-sector interaction and knowledge exchange (Gao & Lim, 2023). Consequently, future urban redevelopment strategies should seek a new balance among spatial diversity, social inclusiveness, and sustained innovation.

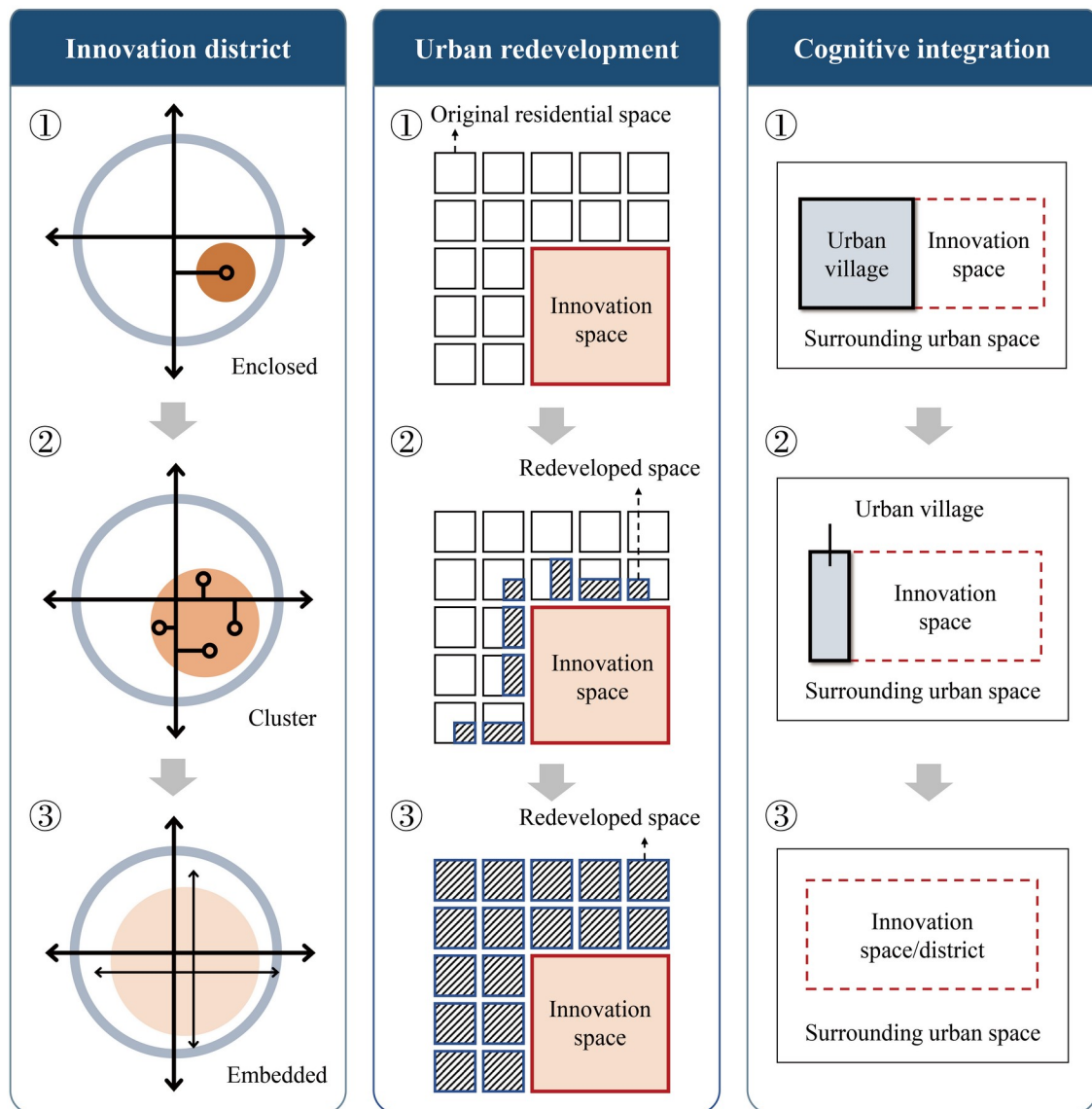


Figure 4. Interpretive framework of cognitive adaptation in innovation-driven urban redevelopment in urban villages.

Conclusion and Discussion

This study adopted the perspective of cognitive regions to analyze how innovation-driven redevelopment promotes the cognitive reconstruction of spatial relations in urban villages at the micro scale. Based on the case of Tangdong Village in Guangzhou, we found that innovation spaces and the original residential spaces of the urban village are still understood by different groups as clearly differentiated spaces, and the two are not yet fully connected at the cognitive level. Original residents, innovation workers, and the external group formed different cognitive regions, with distinct attentional foci, cognitive cores, and place meanings. At the same time, under the spillover effects of innovation spaces, the transition areas between the two types of spaces are being redeveloped, gradually softening people's perceived boundaries between old and new spaces.

The contribution of this study lies in introducing cognitive regions as an analytical perspective for understanding the social impacts of innovation-driven redevelopment. We do not argue that cognitive integration is more important than physical-spatial integration. Rather, we emphasize that physical-spatial

integration can be transformed into socially perceptible and sustainable integration only through different groups' spatial experiences, place meanings, and perceived boundaries. In other words, the cognitive-region perspective complements existing urban redevelopment studies that focus on material space, land governance, housing costs, and community participation. It further reveals how different groups form distinct spatial cores, meaning systems, and perceived boundaries within the same redeveloped area. Moreover, cognitive integration does not necessarily begin within the core residential spaces or core innovation spaces, but may instead emerge first from the connecting areas between old and new spaces.

Although innovation spaces are rooted in local communities, they are primarily oriented toward attracting capital and talent, and their operation depends on local fiscal, political, and cultural resources to support the development of spaces for work, living, and leisure. For communities to play a substantive role within this process, policies must actively identify and respond to residents' interests and needs. Ignoring the social impacts on existing populations or treating them as secondary issues weakens the inclusiveness of urban redevelopment (Kayanan et al., 2022). To ensure that innovation spaces become spaces that benefit society as a whole, the focus should shift from serving knowledge elites to serving the broader public. This includes promoting interaction between knowledge workers and the wider community, and advancing residents' participation from consultation to empowerment (Esmailpoorarabi et al., 2020a). At the same time, attention should be given to transforming the performance paradigm of innovation districts, moving beyond economic indicators such as patents, output value, and employment toward multidimensional evaluations that include social innovation, environmental sustainability, and quality of life (Zhou et al., 2025).

In addition, facing the risks of replacing village identities, the cultural characteristics of urban villages should be valued. During the process of introducing new industries, the transformation of spatial meanings should not be understood as the erasure of the cultural significance of urban villages (Zeng et al., 2020). Instead, it is possible to explore approaches for two-way openness and integration between innovation spaces and the original public spaces of urban villages, allowing creative elements to permeate these existing spaces while making full use of their cultural symbols. Within the current spatial structure, there remains potential for optimizing internal layouts and spatial functions. For instance, access control can be placed at the entrances of enterprise office areas rather than at the overall park boundary, allowing residents limited access to public areas within the innovation compound for leisure activities. At the same time, traditional public spaces such as ancestral halls within the village can serve as venues for corporate cultural events. This approach can help preserve the cultural heritage of urban villages while fostering cognitive integration and emotional connections between the innovation spaces and the village community.

Finally, communities with the insertion of innovation spaces also require locally grounded governance models. As innovation districts remain an evolving strategy, and as they continue to expand across China and globally, policymakers must pay closer attention to their connections with the communities in which they are situated and develop more context-specific planning recommendations for different regions (Kayanan et al., 2022). Efforts to integrate informal settlements into the broader society must also account for the inherent resistance within informal cultures (Marris, 1962). In the Chinese context, the residential spaces of urban villages place strong emphasis on the atmosphere of "home," which highlights the importance of cultivating emotional resonance in public participation during urban village redevelopment (Min Wang et al., 2024). An inclusive city accommodates diverse groups of people, and it is worth considering how to organically promote the integration of different spaces within urban villages in the future, enabling them to become part of the urban system without displacing low-income residents.

This study has several limitations. It adopted an exploratory qualitative approach, and the sample size was relatively limited. Therefore, the findings should not be interpreted as statistically generalizable to all cases of

547 innovation-driven redevelopment in urban villages. Future research could incorporate verification
548 questionnaires with larger samples and draw on existing sense-of-place scales to further measure and cross-
549 validate social integration (Ng et al., 2022), thereby testing and extending the cognitive-region analytical
550 framework proposed in this study.
551

552 Appendix A. Coding scheme for visual content analysis

Main themes	Definition	Subthemes	Definition
Innovation spaces	Photographs primarily depicting spaces, buildings, facilities, or visual elements associated with innovation-related functions, including incubators, maker spaces, entrepreneurial parks, office compounds, and related public areas.	Public spaces	Open or semi-open spaces within or immediately associated with innovation spaces, such as courtyards, plazas, shared outdoor areas, resting areas, or activity spaces.
Innovation spaces	Same as above.	Building facades	Exterior walls, architectural surfaces, entrances, glass walls, renovated buildings, or other facade elements of innovation-related buildings.
Innovation spaces	Same as above.	Signage	Signs, logos, plaques, enterprise names, park entrances, incubator signs, directional boards, or other visual markers indicating innovation-related functions.
Innovation spaces	Same as above.	Street scenes	Streets, lanes, pedestrian paths, internal roads, or everyday street environments located within or immediately around innovation spaces.
Original residential spaces	Photographs primarily depicting the original residential fabric of Tangdong Village, including village houses, residential alleys, local public spaces, street-level services, and everyday living environments.	Public spaces	Public or semi-public spaces used by residents, such as ancestral hall surroundings, small squares, gathering spaces, open areas, or other communal spaces embedded in the residential fabric.
Original residential spaces	Same as above.	Building facades	Exterior walls, balconies, entrances, windows, dense residential buildings, old housing facades, or other architectural surfaces of village residences.
Original residential spaces	Same as above.	Ground-level commercial services	Shops, restaurants, food stalls, grocery stores, repair services, small businesses, or other everyday commercial services located at street level in the residential area.
Original residential spaces	Same as above.	Street scenes	Residential alleys, narrow streets, pedestrian paths, street activities, informal street environments, or everyday circulation spaces within the original residential area.
Transition areas	Photographs primarily depicting interfaces, connecting spaces, or visual juxtapositions between innovation spaces and original residential spaces.	Transition areas between innovation spaces and residential	Streets, passages, edges, interfaces, or scenes where innovation spaces and original residential spaces are visually or spatially connected, adjacent, or contrasted. This includes photographs showing both new and old spatial elements within the same frame

		spaces	or documenting the connection between the two areas.
Peripheries	Photographs primarily depicting spaces located at the edge of Tangdong Village or its surrounding urban context, rather than the core original residential spaces or innovation spaces.	Transportation facilities	Metro stations, bus stops, BRT facilities, major roads, parking areas, road infrastructure, or other transportation-related elements around the village.
Peripheries	Same as above.	Other residences	Residential buildings, commercial housing estates, apartment blocks, or other housing areas located outside or at the edge of the main village fabric.

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