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Article

Research on the Interactive Renewal of Residential Outdoor Spaces in the Context of Aging

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Abstract

Residential outdoor spaces serve as the most significant venue for home-based older adults' outdoor activities. Their livability and age-friendliness have become key topics of active discussion in recent years and a crucial aspect of urban residential renewal. This study focuses on the behavior of older adults and residential outdoor spaces, drawing on theories such as ecological psychology and environment-behavior studies. From an interactive perspective, it explores theoretical methods for the interactive renewal of residential outdoor spaces—including concepts, principles, and an Age-friendly Design Framework. Through field investigations of typical residential samples, the study examines the interaction process between older adults and outdoor spaces, identifies existing issues, and demonstrates the feasibility of integrating interactive renewal with outdoor space design. Furthermore, it proposes design strategies for the age-friendly renewal of residential outdoor spaces, thereby supplementing research on the "space-behavior" interaction and enhancing the overall age-friendly quality of residential environments.

Keywords: residential outdoor spaces; older adults; behavior; interactive renovation; age-friendly design framework

1. Background and Significance

With the implementation of the national strategy to actively address population aging, the Central Committee of the Communist Party of China and the State Council have advocated for a positive approach to aging and the concept of healthy aging, aiming to meet the diverse and high-quality healthcare and elderly care needs of the older population in the new era. Against this backdrop, addressing the challenges of healthy aging has attracted significant attention[2]. Multiple provinces and regions have adopted policies to "support home-based care," which is recognized as the most practical and effective elderly care model globally and remains the predominant approach in China[3].

Constrained by physical limitations, home-based older adults predominantly conduct their outdoor activities within residential communities[4]. Consequently, residential outdoor spaces have become the most critical venues for age-friendly outdoor engagement. However, due to a lack of dynamic understanding of the evolving needs of older adults and their spatial environment[5], the foundational age-friendliness of outdoor spaces in urban residential areas—constructed across various periods—remains fundamentally weak[6]. Prevalent issues include poor environmental quality, a lack of accessible facilities, and insufficient spaces for collective activities. These problems reflect a mismatch in the development of various elements and a neglect of the Design for All principle[7], which, to some extent, hinders the occurrence of healthy outdoor activities among the elderly. Against the backdrop of the shift toward a "stock renewal" [8]development model in urban residential areas and in alignment with the development of complete communities, promoting the

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age-friendly renewal of existing residential outdoor spaces will positively impact the creation of high-quality residential environments and the physical and mental well-being of older adults.

A substantial body of research has demonstrated the significant impact of residential outdoor activities on older adults, revealing notable benefits for their social health[9]. For instance, Zhou Lan et al. found that the landscape environment in outdoor spaces directly influences older adults' health perceptions[10]. Similarly, Di Feng et al. reported that outdoor activities contribute positively to their physical and mental well-being[11]. Conversely, poor-quality residential outdoor spaces can hinder these activities, thereby adversely affecting health. In particular, Zhang Dongqing highlighted that age-friendly issues are most acute in old residential communities, where older adults often lack adequate opportunities for physical exercise in outdoor areas[12].

Research on interactivity was initially concentrated in the fields of software engineering and human-computer interaction (HCI), focusing on usability evaluation and user behavior. Furthermore, it extended into affective aspects, cognitive psychology, educational psychology, human settlements, environmental psychology, and behavioral science. Interactive research primarily examines how the environment influences individual behavior. For example, in the spatial design of institutional elderly care buildings, studies have derived optimized interior strategies by analyzing how furniture arrangements in different functional areas affect usage patterns among older adults[13].Within the domain of human settlements, research explores how new technologies can be applied to interior spaces, spatial layouts, buildings, and transportation systems to influence both the built environment and its inhabitants. For instance, in residential interior design, He Lei concluded that functionality, artistry, and communicability are core values of interactivity, while digitalization, emotionalization, and sustainability represent future trends in interactive design[14]. Additionally, interactive design has been employed to enhance residential and social experiences through intelligent connected facilities and personalized visual information. For example, Wang Yao applied interaction theory to urban public spaces, utilizing artificial intelligence to create interactive art installations. This approach not only provides novel interactive experiences between people and the environment but also promotes the upgrade of public space design[15].

Existing research on interactivity primarily prioritizes functionality, employing traditional interactive research methods to achieve human-environment interaction based on predefined rules, which necessitates further exploration in practice and application. In contrast, the study on interactive renewal of residential outdoor spaces within the context of aging challenges the conventional unidirectional cause-and-effect framework—whether direct outcomes of subject behavior or indirect results of subjective experience. Instead, it places the interactive experience between the subject and object at the core. By adopting a synergistic approach that integrates forward-thinking design with reverse evaluation, this research aims to refine the logical framework of interactive renewal design.

The study focuses on the following four aspects: (1) conceptualizing interaction, affordance, and evaluative factors from the perspectives of ecological psychology and environment-behavior studies; (2) analyzing relevant theoretical principles and examining the methodological framework of the research; (3) applying the theoretical approach to residential outdoor spaces, conducting field investigations in sample communities to deeply examine interaction processes and identify factors influencing the quality of interaction between older adults and outdoor environments; (4) proposing an interactive age-friendly renewal design strategy for residential outdoor spaces based on the identified influencing factors and interaction elements. The research aims to provide precise improvement recommendations grounded in the determinants of interaction quality, offering a novel perspective and methodological approach for the age-friendly renewal design of residential outdoor spaces.

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2. Theoretical and Methodological Framework for Interactive Renewal of Residential Outdoor Spaces in the Context of Aging and Interaction

2.1. Theoretical Foundations

Rooted in interaction theory and affordance theory, ecological psychology emphasizes the interactivity between humans and their environment, positing that human cognition and behavior are intrinsically linked to environmental affordances. Its applications span diverse settings, including natural environments, social contexts, and even designed products and service environments. Furthermore, ecological psychology underscores the perception of the behavioral setting. Understanding the interplay between behavior and the environment serves as a key methodological approach in this study, enabling the construction of a comprehensive research framework.

Interactivity primarily reveals the interactive relationship between user behavior and the environment, comprehensively addressing the dynamic integration and causal relationships between behavior and space, thereby fostering an optimal state of coordination between humans and their environment. Affordance refers to the capacity of objects and settings within the environment to prompt and guide human actions and behaviors.

Environment-Behavior Studies is a discipline that examines the interplay between human cognitive and behavioral characteristics and environmental factors. It draws upon and applies psychological theories, Post-Occupancy Evaluation (POE) theory, and other relevant academic frameworks and methodologies, with particular emphasis on behavior, environmental perception, and their mutual interaction. Within the current global context advocating sustainable development, the primary research objectives of Environment-Behavior Studies focus on understanding individual behavioral patterns and decision-making processes under specific environmental conditions, and further investigating how people adjust their behaviors in response to environmental factors. This study applies this approach to examine the behaviors of older adults within residential outdoor spaces. Furthermore, driven by the imperative of sustainability, the scope of Environment-Behavior Studies has expanded to include in-depth research within the field of human settlements, providing theoretical support and methodological guidance for urban planners, architects, and designers in these domains. Grounded in the above theories, this research employs field investigations, behavioral observation, quantitative analysis, and matrix evaluation methods to construct an interactive research framework and propose interactive renewal strategies.

2.2. Basic Principles and Methods of Affordance Evaluation

Affordance is highly dependent on the user. The interaction process itself constitutes a cyclical loop of information exchange between older adults and residential outdoor spaces, with the behavior of the elderly at its core. Therefore, the fundamental principle for quantifying interactive renewal design in residential outdoor spaces is as follows (Figure 1): older adults, influenced by the residential outdoor space, engage in behaviors within a given setting. These behaviors, driven by both external spatial conditions and internal psychological needs, result in specific forms of feedback. Based on this immediate feedback and their assessment of the new context, older adults then initiate subsequent actions, thereby forming a continuous cycle of triggering and responding within the interaction process.Furthermore, emotion serves as a psychological reflection of the interaction between older adults and space, representing a quantifiable measure of the effect during the triggering process. The PANAS (Positive Affect and Negative Affect Scale) and the Visual Analogue Scale (VAS) (Figure 2) are used to measure the emotional responses of older adults to outdoor spaces within residential areas, aiming to analyze the extent to which these spaces elicit psychological and emotional reactions. The PANAS scale is an internationally recognized emotional assessment tool[16], and its Chinese version has demonstrated good reliability and validity[17]. This study employs 10 commonly used positive and negative emotions from the scale, with numerical values indicating the intensity of each emotion. The Visual Analogue Scale uses a straight line to represent the degree of a specific emotion,

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where moving left indicates lower intensity and moving right indicates higher intensity. This method is applied in this study to measure five distinct emotions among older adults using residential outdoor spaces.

In the interaction process, this study draws upon the factor analysis method developed by Tan Shaohua et al[18]. for assessing stress alleviation in pocket parks, which has been adapted according to the characteristics of age-friendly outdoor spaces in residential areas. Four factors—functional, emotional, behavioral, and sensory—are extracted as interactive mediators between older adults and residential outdoor spaces. The functional factor refers to the convenience and suitability of residential outdoor spaces, primarily related to spatial group structures. The emotional factor reflects the sense of security experienced by older adults when using facilities, corresponding to elements of environmental infrastructure. The behavioral factor examines whether spatial characteristics support free and comfortable outdoor activities, mainly involving spatial/path hierarchy types. The sensory factor pertains to the comfort experience of outdoor spaces, such as physical and aesthetic perceptions, corresponding to landscape quality.

The wishes and needs of older adults are expressed as affordances. Within the complex relationships of human-environment interaction, these can be categorized into three aspects: Space, Artifact, and User[19](Figure 1). These interactive relationships include the triggering from space to the user, termed SUA (Space-User-Affordance), and the feedback from the user to the space, termed USA (User-Space-Affordance). For example, easily accessible spaces may encourage older adults to engage in various non-interfering resting behaviors, representing a positive trigger. Conversely, when spaces are poorly accessible, older adults may modify or adjust spatial functions on their own, reflecting negative feedback. Additionally, the lack of facilities in easily accessible spaces may prevent the realization of potential affordances, indicating latent interaction. The corresponding manifestations are denoted as ±SUA, ±AUA, ±USA, and ±UAA. The quality of the interaction process is quantitatively evaluated through an affordance evaluation matrix designed for older adults.

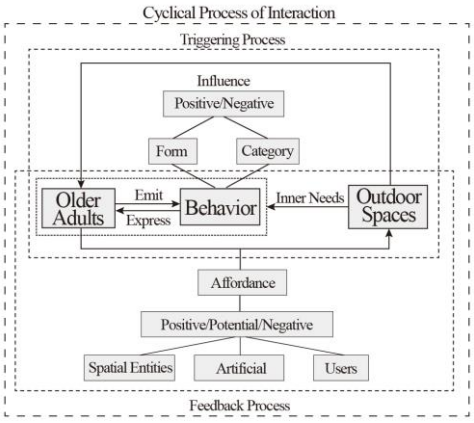

Figure 1. Interactivity Mechanism of Residential Outdoor Spaces.

Figure 2. Schematic diagram of the Visual Analogue Scale.

2.3. Research Framework for Interactive Renewal in the Context of Aging Interaction

Drawing on Barker's research methods and Gibson's "theory of ecological perception," a framework for age-friendly interactive design of residential outdoor spaces has been established. A review of relevant domestic and international research indicates that most studies tend to favor qualitative analysis, with methodology predominantly guided by empiricism, which has certain limitations. Behavioral observation and description alone are insufficient to delve into the psychological dimensions of older adults.

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Therefore, based on theories of ecological psychology and environment-behavior studies, a research framework has been developed (Figure 3). This framework positions older adults as the interactive subject and residential outdoor spaces as the interactive object. Two typical residential communities are selected as study samples, focusing on the daily outdoor activities of older adults as the core of interactive renewal. Factor analysis, combined with quantitative and qualitative methods, is used to analyze the characteristics of the triggering and feedback phases in the interaction between older adults and residential outdoor spaces. The study further investigates and analyzes issues within the interaction process and their underlying causes, ultimately proposing an interactive age-friendly renewal design strategy for residential outdoor spaces in the context of population aging.

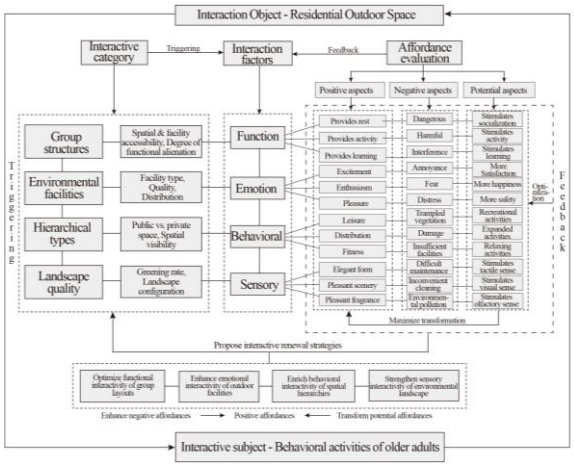

Figure 3. Interactive Renewal Age-friendly Design Framework for Residential Outdoor Spaces.

3. Interactive Research on Residential Outdoor Spaces in the Context of Aging Interaction

3.1. Sample Selection

During the preliminary research phase, residential areas in Wuhan with a high degree of population aging—where communities have transitioned into an aged or even super-aged demographic (with over 15% of the population aged 65 and above)[20]—were randomly selected for initial field surveys. Subsequently, based on collected data and considerations of typicality, two adjacent residential communities in Wuhan's Dadongmen area—the Railway Dadongmen Community and the Fuel Community—were ultimately chosen as sample sites (Figure 4). Both communities were constructed in the 1990s, share similar spatial layouts, and are characterized by high population density, a strong neighborhood atmosphere, abundant outdoor public spaces, and significant levels of outdoor activity among older adults. However, they differ in scale, while their outdoor spaces generally exhibit mediocre hierarchical typology and landscape quality.In terms of spatial layout, both communities primarily feature multi-story linear building arrangements (Figure 5). The outdoor spaces encompass three types: points (facilities), lines (paths), and areas (squares and interstitial open spaces).

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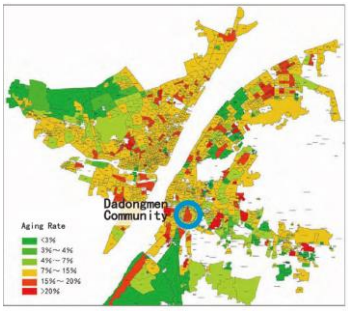
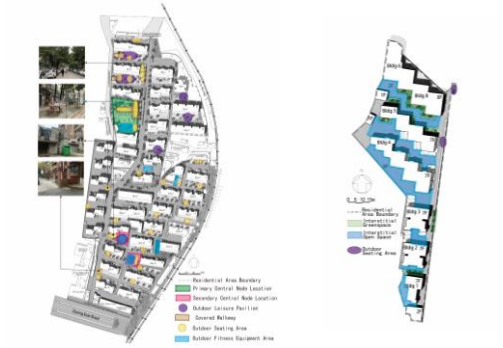


Figure 4. Aging Rate in Dadongmen Community.



(**a**) (**b**)

Figure 5. Current Residential Outdoor Spaces. (**a**) Current Outdoor Spaces in Railway Dadongmen Community; (**b**) Current Outdoor Spaces in Fuel Community.

3.2. Survey and Analysis Methods

3.2.1. Indicator System Design

The indicator system comprises two key aspects. On one hand, the Residential Outdoor Activity Characteristic Indicator System (Table 1) focuses on the attributes of the interactive subjects. It categorizes the outdoor activity patterns of older adults in residential areas into three components: temporal characteristics, spatial characteristics, and behavioral characteristics. To account for the regular outdoor activity patterns of older adults, survey periods were scheduled on both weekdays and weekends during both winter and summer, with all surveys conducted during daytime hours.

On the other hand, the Interactive Renewal Design Indicator System for Residential Outdoor Spaces (Table 2) concentrates on the typology of outdoor spaces. It classifies outdoor spaces into point-based (primarily facilities), linear (mainly paths), and areal (including interstitial open spaces, squares, etc.). A subjective evaluation of spatial environmental quality is conducted across three hierarchical levels, with indicators for each sample space derived through a combination of qualitative and quantitative analysis.

Table 1. Older Adults' Activity Characteristics Indicator System.

	Characteristic Category	Research Elements	Data Collection Method
Older Adults' Outdoor Activity Characteristics Indicator System	Temporal characteristics	Time distribution Duration of time	Questionnaire interview Behavior observation Timed photography
	Spatial characteristics	Spatial distribution Spatial facilities Spatial greenery Site flatnessg	GPS positioning watch Photographic recording

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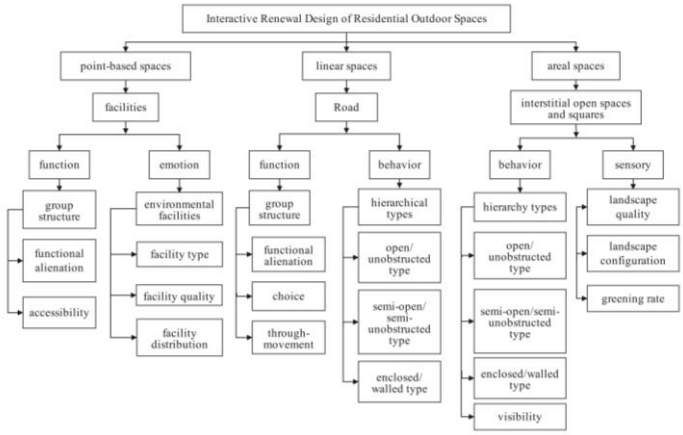
	Behavioral characteristics	Behavior types Behavior preferences Facility distribution	Questionnaire interview Timed photography

Table 2. Interactive Renewal Design Indicator Framework for Residential Outdoor Spaces.



3.2.2. Survey Methodology

The investigation for the study on interactive renewal of residential outdoor spaces employed the following methodology: First, field surveys were conducted to create planar CAD files based on on-site measurements. Second, using the design measurements, spatial syntax analysis was applied to generate axial maps, segment models, and visibility graph analysis models. Finally, the PSPL survey method (Public Space & Public Life Survey) was implemented, which consists of three components: public space analysis, public life investigation, and summary with recommendations. The questionnaire survey involved unstructured interviews with older adults aged 60 and above. A total of 230 questionnaires were distributed, with 220 collected and 216 valid responses used for analysis (including basic questionnaires and the PANAS scale). Additionally, a combined method using GPS positioning watches and behavioral observation records was employed to track the subjects, resulting in the collection of 400 datasets.

3.3. Results and Discussion

3.3.1. Environmental Characteristics of Outdoor Spaces in Sample Residential Areas

The interactive objects within the communities exhibited high frequency and intensity of use. Greening was predominantly comprised of street trees, supplemented by patchy greenery in front of dwellings, with overall relatively poor quality. The general outdoor spatial structure was primarily enclosed, with open-type spaces serving as a secondary form.In the Railway Dadongmen Community (Figure 5), point-based spaces (including 8 leisure pavilions and corridors, 6 fitness areas, and seating beside interstitial spaces) and areal spaces (interstitial spaces and 3 plazas) were dominant, while linear spaces (one main north-south road serving both traffic and daily functions, with branch roads forming a fishbone pattern) were supplementary. In the Fuel Community (Figure 5), linear spaces (one main north-south road with fishbone-patterned branches) and areal spaces (interstitial areas) were primary, while point-based spaces (2 seating areas) were secondary.Spatial syntax analysis of measured data produced axial, segment, and visibility models (Figures 6–8), revealing that main roads in both communities showed high connectivity and good accessibility. These spaces were relatively open with minimal visual barriers and substantial pedestrian flow. Areal spaces in Railway Dadongmen and point-based spaces in Fuel demonstrated higher permeability. Conversely, branch roads in both communities exhibited gradually decreasing accessibility with

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lower pedestrian flow. Areal spaces in eastern Railway Dadongmen and linear spaces in northwestern Fuel showed reduced visibility due to obstructions from building profiles and vegetation.

(**a**) (**b**)

Figure 6. Choice analysis of residential areas. (**a**) Choice analysis of Railway Dadongmen Community; (**b**) Choice analysis of Fuel Community.

(**a**) (**b**)

Figure 7. Global integration overlayed with central nodes and interstitial space data. (**a**) Global integration overlayed with central nodes and interstitial space data - Railway Dadongmen Community; (**b**) Global integration overlayed with interstitial space data - Fuel Community.

(**a**) (**b**)

Figure 8. Spatial visibility overlayed with outdoor public facility distribution data. (**a**) Spatial visibility overlayed with outdoor public facility distribution - Railway Dadongmen Community; (**b**) Spatial visibility overlayed with outdoor public facility distribution - Fuel Community.

3.3.2. Behavioral Characteristics of Older Adults in Residential Areas

The outdoor activities of older adults demonstrate distinct temporal patterns, primarily concentrated in three periods: morning (8:00–11:00), afternoon (14:00–17:00), and evening (19:00–22:00) (Figures 9–11). Activity types are categorized into solitary and group-based, and further

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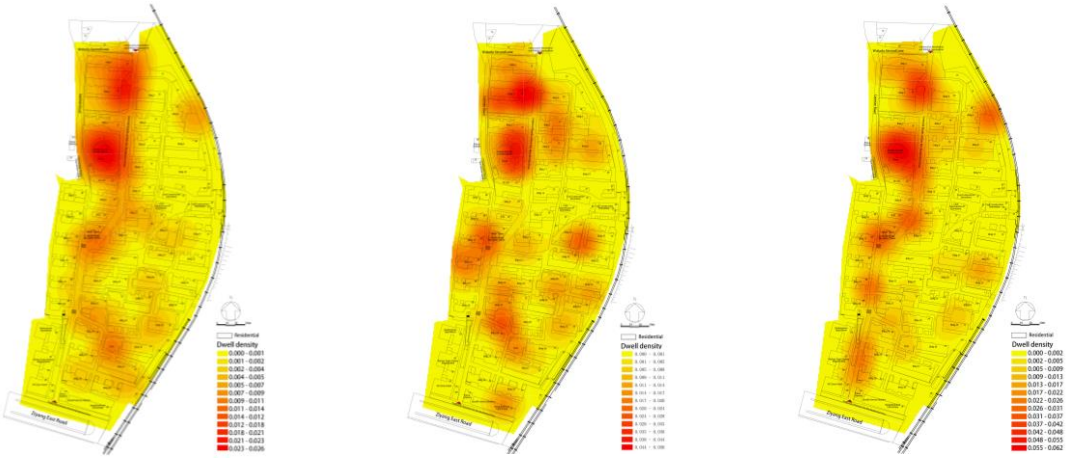
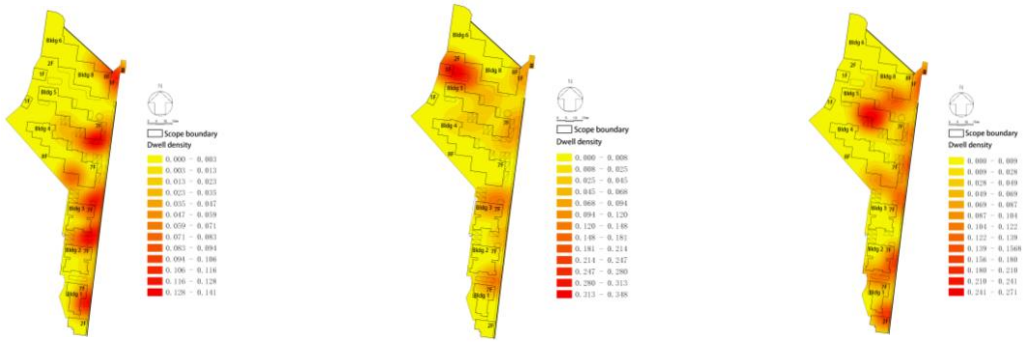
classified by content into transitory and stationary forms. The main outdoor activities can be broadly divided into five categories: leisure, social interaction, quiet observation, personal tasks, and parent-child activities (Figure 12, Table 3). In the morning, activities such as exercise, instrumental performances, grocery shopping, and grandchild care are more frequent. Afternoons are dominated by social behaviors such as quiet observation, chess/card games, and chatting, while evenings are primarily dedicated to leisure activities such as exercise, walking, and brisk walking.



(**a**) (**b**) (**c**)

Figure 9. Heat Map of Older Adults' Outdoor Activities in Railway Dadongmen Community**.** (**a**) 8:00-11:00 at Railway Dadongmen Community; (**b**) 14:00-17:00 at Railway Dadongmen Community; (**c**) 19:00-22:00 at Railway Dadongmen Community.



(**a**) (**b**) (**c**)

Figure 10. Heat Map of Older Adults' Outdoor Activities in Fuel Community. (**a**) 8:00-11:00 at Fuel Community; (**b**) 14:00-17:00 at Fuel Community; (**c**) 19:00-22:00 at Fuel Community.

Table 3. Outdoor Activity Types of Older Adults in Railway Dadongmen Community and Fuel Community.

Type	Abbreviation	Form	Hierarchy	Specific Activities
Leisure	X-1	Stagnant	Individual	Listening to radio, reading books/newspapers, playing accordion, listening to music, etc.
	X-2	Stagnant	Group-based	Playing cards, chess, badminton, square dancing, etc.
	X-3	Transitory	Individual	Taking a walk, power walking, walking the dog, etc.
Social	S	Stagnant	Group-based	Greeting others, sitting and chatting, stopping to chat, etc.

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Quiet Observation	J	Stagnant	Individual	Sitting quietly, leaning against something, standing still, waiting for someone, watching others' activities, etc.
Parent-child	Q-1	Stagnant	Group-based	Playing with children, making friends, etc.
	Q-2	Transitory	Individual	Taking children for a walk, exercising, etc.
Personal Tasks	G	Transitory	Individual	Grocery shopping, supermarket purchases, taking out the trash, picking up grandchildren, doing household chores, etc.

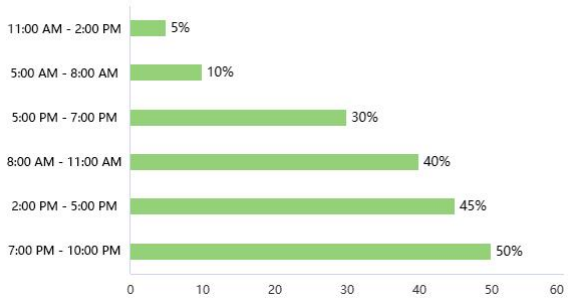

Figure 11. Daily Outdoor Activity Schedule of Older Adults.

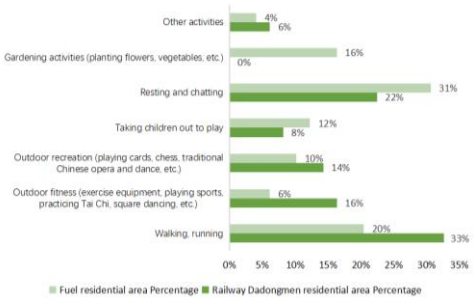

Figure 12. Statistics of Activity Types Among Older Adults in the Residential Communities.

3.3.3. Analysis of Incompatibility Between Residential Outdoor Spaces and Spatiotemporal Behavior of Older Adults

(1) Point-based Spaces

The accessibility, quality, and type of point-based spaces are positively correlated with the behavior types of older adults. From the perspective of the functional factor, significant feedback effects between the subject and object during certain interaction processes have led to phenomena such as the functional alienation of facilities (e.g., being used for hanging objects) or the self-adaptive behavior of residents installing their own outdoor seating (Figure 13). This is particularly evident in linear-layout residential areas, where negative affordances constitute a considerable proportion in the feedback matrix. Furthermore, negative affordances exist in every type of interaction within the residential areas (Tables 4, 5).Regarding the emotional factor, in larger linear-layout residential areas, the uneven distribution of facilities in terms of location and quantity, coupled with irrational location planning in smaller linear-layout areas, reduces facility accessibility and usage frequency, leading to the isolation of some newly constructed facilities. In larger linear-layout communities, point-based spaces in the southwestern part appear "cold" in thermal mapping and remain largely unused. In smaller linear-layout communities, the frequency of changes in activity types among older adults is

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relatively high, with concentrations near leisure seating adjacent to dwellings.The investigation reveals that the selection of point-based spaces by older adults is influenced not only by the distribution, quantity, and quality of the facilities themselves but also significantly by the pavement flatness around these spaces and their accessibility. While outdoor activities require considerable physical effort and can easily induce fatigue—and although most older adults experience effectively stimulated positive emotions after outdoor activities (Tables 6, 7)—the lack of accessible facilities and uneven pavement surfaces still contribute to increased feelings of fear and worry among some older adults, particularly those with declining mobility or those who are assistive-device-dependent, after their activities (Tables 8, 9). These factors are identified as major barriers to outdoor engagement.

Figure 13. Self-installed seating by older adults and modification of existing seats into L-shaped or four-sided enclosed layouts.

Table 4. Affordance Evaluation Matrix for Outdoor Spaces in Railway Dadongmen Community.

Affordance Category	Affordance Occurrence	SUA(Triggering)		USA(Feedback)		Quantity Statistics			Score	Total	Overall
		SUA_1	AUA	USA_1	UAA	Positive Affordance	Potential Affordance	Negative Affordance	Affordance Quantity	Individual Score	Total Score
Functional Affordance	Positive Affordance	+			+	2			7	2	-1.5
	Potential Affordance		#				1			0.5	
	Negative Affordance	-	-	-	-			4		-4	
Behavioral Affordance	Positive Affordance	+			+	2			8	2	-1
	Potential Affordance		#		#		2			1	
	Negative Affordance	-	-	-	-			4		-4	
Emotional Affordance	Positive Affordance	+				1			4	1	-0.5
	Potential Affordance	#					1			0.5	
	Negative Affordance		-		-			2		-2	

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Sensory Affordance	Positive Affordance	+				1			6	1	-1
	Potential Affordance		#	#			2			1	
	Negative Affordance	-		-	-			3		-3	
Quantity Statistics	Positive Affordance	4			2	6			25	6	
	Potential Affordance	1	3	1	1		6			3	
	Negative Affordance	3	3	3	4			13		-13	
	Total	8	6	4	7	25					
Score		1.5	-1.5	-2.5	-1.5	6	3	-13		-4	-4

Table 5. Affordance Evaluation Matrix for Outdoor Spaces in Fuel Community.

Affordance Category	Affordance Occurrence	SUA(Triggering)		USA(Feedback)		Quantity Statistics			Score	Total	Overall
		SUA_1	AUA	USA_1	UAA	Positive Affordance	Potential Affordance	Negative Affordance	Affordance Quantity	Individual Score	Total Score
Functional Affordance	Positive Affordance	+		+		2			7	2	-1.5
	Potential Affordance	#					1			0.5	
	Negative Affordance	-	-	-	-			4		-4	
Behavioral Affordance	Positive Affordance	+	+			2			7	2	-1.5
	Potential Affordance		#				1			0.5	
	Negative Affordance	-	-	-	-			4		-4	
Emotional Affordance	Positive Affordance	+				1			6	1	-2.5
	Potential Affordance			#			1			0.5	

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	Negative Affordance	-	-	-	-			4		-4	
Sensory Affordance	Positive Affordance			+		1			6	1	-2.5
	Potential Affordance	#					1			0.5	
	Negative Affordance	-	-	-	-			4		-4	
Quantity Statistics	Positive Affordance	3	1	2		6			26	6	
	Potential Affordance	2	1	1			4			2	
	Negative Affordance	4	4	4	4			16		-16	
	Total	9	6	7	4	26					
Score		0	-2.5	-1.5	-4	6	2	-16		-8	-8

Table 6. Emotions Measured with PANAS Scale Before and After Outdoor Activities in Railway Dadongmen Community.

	Emotions Before Going Out to Residential Outdoor Spaces					Emotions Upon Leaving Residential Outdoor Spaces After Activity				
	Not at all/Very Slight (0)	A Little (1)	Moderately (2)	Quite a Bit (3)	Extremely (4)	Not at all/Very Slight (0)	A Little (1)	Moderately (2)	Quite a Bit (3)	Extremely (4)
1.Distressed/Upset	48(44.4%)	18 (16.7%)	18 (16.7%)	18 (16.7%)	6 (5.6%)	60 (55.6%)	48 (44.4%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
2.Excited	6(5.6%)	36 (33.3%)	36 (33.3%)	18 (16.7%)	12 (11.1%)	0 (0.0%)	24 (22.2%)	64 (44.4%)	18 (16.7%)	18 (16.7%)
3.Scared	72 (66.7%)	24 (22.2%)	12 (11.1%)	0 (0.0%)	0 (0.0%)	90 (83.3%)	18 (16.7%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
4.Enthusiastic	6 (5.6%)	24 (22.2%)	18 (16.7%)	12 (11.1%)	18 (16.7%)	0 (0.0%)	24 (22.2%)	54 (50.0%)	12 (11.1%)	18 (16.7%)
5.Sensitive	66 (61.1%)	30 (27.8%)	6 (5.6%)	0 (0.0%)	6 (5.6%)	60 (55.6%)	28 (38.9%)	0 (0.0%)	6 (5.6%)	0 (0.0%)
6.Active	0 (0.0%)	18 (16.7%)	42 (38.9%)	30 (27.8%)	18 (16.7%)	0 (0.0%)	12 (11.1%)	54 (50.0%)	36 (33.3%)	6 (5.6%)

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7.Nervous	60 (55.6%)	48 (44.4%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	72 (66.7%)	24 (22.2%)	6 (5.6%)	6 (5.6%)	0 (0.0%)
8.Determined	6 (5.6%)	48 (44.4%)	36 (33.3%)	0 (0.0%)	18 (16.7%)	6 (5.6%)	64 (44.4%)	42 (38.9%)	0 (0.0%)	12 (11.1%)
9.Depressed / Unhappy	84 (77.8%)	24 (22.2%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	78 (72.2%)	18 (16.7%)	6 (5.6%)	6 (5.6%)	0 (0.0%)
10.Afraid / Worried	78 (72.2%)	24 (22.2%)	6 (5.6%)	0 (0.0%)	0 (0.0%)	66 (61.1%)	42 (38.9%)	0 (0.0%)	0 (0.0%)	0 (0.0%)

Table 7. Emotions Measured with PANAS Scale Before and After Outdoor Activities in Fuel Community.

	Emotions Before Going Out to Residential Outdoor Spaces					Emotions Upon Leaving Residential Outdoor Spaces After Activity				
	Not at all/Very Slight (0)	A Little (1)	Moderately (2)	Quite a Bit (3)	Extremely (4)	Not at all/Very Slight (0)	A Little (1)	Moderately (2)	Quite a Bit (3)	Extremely (4)
1.Distressed/Upset	0 (0.0%)	0 (0.0%)	24 (22.2%)	72 (66.7%)	12 (11.1%)	12 (11.1%)	24 (22.2%)	48 (44.4%)	24 (22.2%)	0 (0.0%)
2.Excited	0 (0.0%)	48 (44.4%)	36 (33.3%)	24 (22.2%)	0 (0.0%)	12 (11.1%)	0 (0.0%)	24 (22.2%)	48 (44.4%)	24 (22.2%)
3.Scared	36 (33.3%)	0 (0.0%)	36 (33.3%)	36 (33.3%)	0 (0.0%)	36 (33.3%)	36 (33.3%)	36 (33.3%)	0 (0.0%)	0 (0.0%)
4.Enthusiastic	36 (33.3%)	24 (22.2%)	24 (22.2%)	12 (11.1%)	12 (11.1%)	36 (33.3%)	12 (11.1%)	48 (44.4%)	12 (11.1%)	0 (0.0%)
5.Sensitive	36 (33.3%)	36 (33.3%)	24 (22.2%)	12 (11.1%)	0 (0.0%)	72 (66.7%)	0 (0.0%)	24 (22.2%)	12 (11.1%)	0 (0.0%)
6.Active	0 (0.0%)	60 (55.6%)	36 (33.3%)	0 (0.0%)	12 (11.1%)	0 (0.0%)	24 (22.2%)	0 (0.0%)	12 (11.1%)	72 (66.7%)
7.Nervous	12 (11.1%)	60 (55.6%)	12 (11.1%)	12 (11.1%)	12 (11.1%)	84 (77.8%)	0 (0.0%)	0 (0.0%)	12 (11.1%)	12 (11.1%)
8.Determined	24 (22.2%)	60 (55.6%)	12 (11.1%)	12 (11.1%)	0 (0.0%)	12 (11.1%)	60 (55.6%)	24 (22.2%)	12 (11.1%)	0 (0.0%)
9.Depressed / Unhappy	72 (66.7%)	12 (11.1%)	12 (11.1%)	0 (0.0%)	12 (11.1%)	96 (88.9%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	12 (11.1%)
10.Afraid / Worried	12 (11.1%)	48 (44.4%)	0 (0.0%)	48 (44.4%)	0 (0.0%)	0 (0.0%)	24 (22.2%)	0 (0.0%)	60 (55.6%)	24 (22.2%)

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Table 8. Emotions Measured Using the Visual Analogue Scale Before Outdoor Activities and Upon Leaving the Activity Space in the Railway Dadongmen and Fuel Communities.

		Emotions Before Going Out to Residential Outdoor Spaces				Emotions Upon Leaving Residential Outdoor Spaces After Activity			
Emotion	Community	Min	Max	Mean	Variance	Min	Max	Mean	Variance
1.Stressed	Railway Dadongmen	0.0	7.0	1.456	5.018	0.0	7.5	2.222	5.565
	Fuel	5.0	8.8	7.000	1.723	0.0	8.0	5.133	6.848
2.Anxious	Railway Dadongmen	0.0	8.0	3.022	6.962	0.0	4.2	1.565	1.898
	Fuel	5.0	8.1	6.733	1.173	0.0	7.5	5.111	4.894
3.Depressed	Railway Dadongmen	0.0	8.5	2.389	6.310	0.0	6.5	1.567	3.009
	Fuel	5.1	7.5	6.389	1.546	4.0	6.0	4.733	0.418
4.Relaxed	Railway Dadongmen	0.0	9.0	4.472	10.749	0.0	9.0	4.694	9.563
	Fuel	2.0	5.6	3.900	1.230	4.0	9.0	6.444	2.853
5.Content	Railway Dadongmen	0.0	7.5	4.139	5.524	1.3	8.8	4.844	6.028
	Fuel	3.0	7.1	5.200	1.538	0.0	9.2	6.256	8.340

Table 9. Oifference in Emotional Changes After Outdoor Activities Among Older Adults in Railway Dadongmen and Fuel Communities.

	Min		Max		Mean		Variance	
Emotion	Railway Dadongmen	Fuel	Railway Dadongmen	Fuel	Railway Dadongmen	Fuel	Railway Dadongmen	Fuel
Distressed/Upset	-3.00	-3.00	1.00	2.00	-0.780	-1.333	1.477	2.000
Excited	-2.00	-2.00	3.00	3.00	0.390	1.111	2.016	2.611
Scared	-2.00	0.00	1.00	2.00	-0.280	-0.222	0.683	2.194
Enthusiastic	-3.00	-1.00	2.00	3.00	0.110	1.111	1.752	1.111
Sensitive	-3.00	-1.00	3.00	1.00	0.000	-0.444	1.765	0.528
Active	-2.00	0.00	1.00	3.00	1.100	2.222	1.399	1.194
Nervous	-1.00	-2.00	2.00	3.00	0.060	-0.778	0.997	2.194
Determined	-3.00	-1.00	3.00	1.00	1.100	0.333	1.987	0.500
Depressed / Unhappy	-1.00	-2.00	2.00	0.00	0.330	-0.444	0.706	0.528
Afraid / Worried	-2.00	-3.00	1.00	3.00	0.600	1.222	0.644	2.944
Stressed	-3.00	-4.00	6.00	2.30	0.767	-1.433	6.256	5.243
Anxious	-6.00	-2.80	3.00	1.50	-1.483	-1.244	6.420	1.420
Depressed	-5.50	-2.00	6.50	1.80	-0.822	-1.256	8.722	1.418
Relaxed	-5.00	-1.00	6.50	5.00	0.222	2.322	9.801	3.327
Content	-5.00	-1.40	4.50	4.30	0.706	1.511	5.736	2.346

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(2) Linear Spaces

The choice, through-movement, and openness of linear spaces show a positive correlation with the behavioral hierarchy of older adults (Figures 7 and 14). From the perspectives of functional and behavioral factors, the main roads within the communities exhibit high connectivity values and considerable openness, facilitating rich transitions between individual and group-based behavioral levels among older adults (Figures 15 and 16), with various affordances being easily identifiable (Table 5). While the emotional states of older adults tend to improve along the main roads, the lack of vehicle-pedestrian segregation poses significant challenges. Given that most older adults move slowly, experience hearing impairment, and have weakened emergency response capabilities, their activity range and route choices are considerably constrained during morning and evening peak hours, leading to a noticeable increase in negative emotions.In contrast, the choice and through-movement of branch roads gradually decrease. These narrower paths are predominantly semi-enclosed, with some fully enclosed segments, resulting in relatively low visibility. They offer limited space for individual leisure or group social activities. Consequently, older adults primarily use these branch roads for transitory activities such as exercise, leisure, or personal tasks, with stationary behaviors being less frequent. The richness of behavioral transitions diminishes significantly along these routes, accompanied by lower affordance scores. Furthermore, within the axial models of smaller linear-layout communities, linear spaces appearing "cold" in the analysis demonstrate low accessibility. The layout of these linear spaces fails to accommodate the declining physical capabilities of the aging population, showing poor alignment with actual needs and suffering from insufficient spatial triggering.

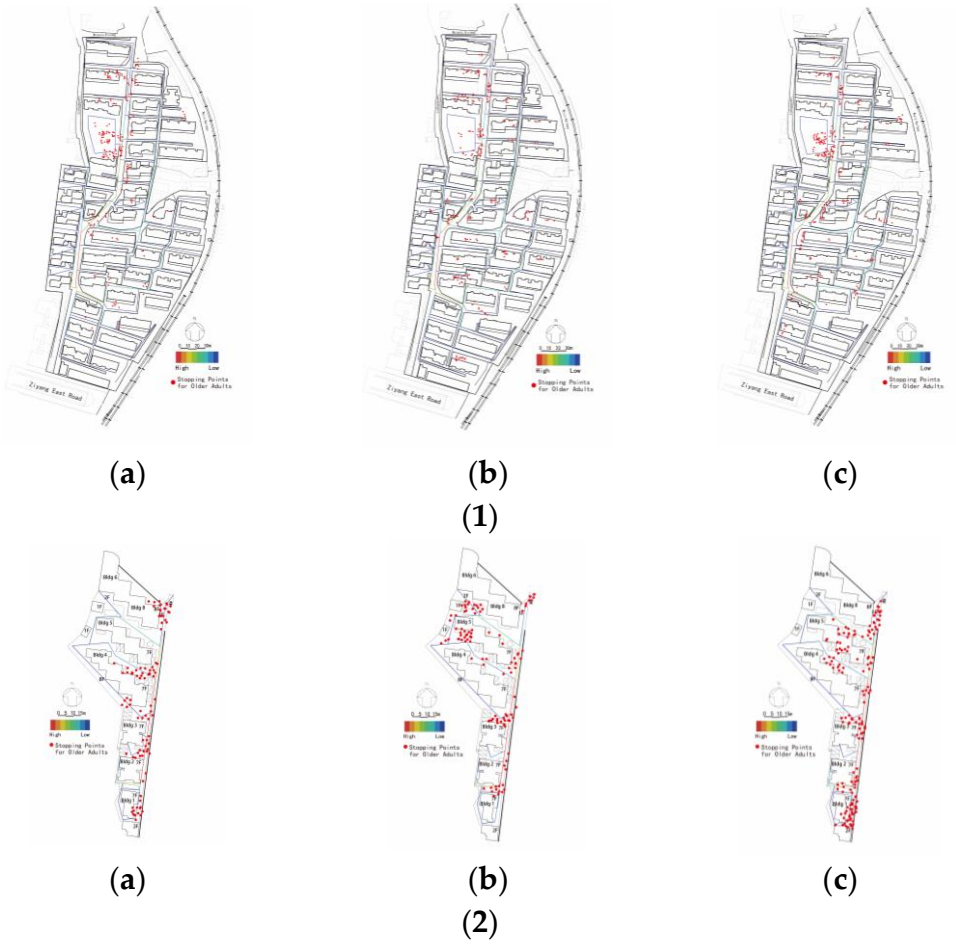

Figure 14. Choice and Temporal Activity Distribution of Older Adults in Residential Communities. (**1**) TChoice and Temporal Activity Distribution of Older Adults - Railway Dadongmen Community; (**a**) Choice and Older Adults' Morning Activity Distribution; (**b**) Choice and Older Adults' Afternoon Activity Distribution; (**c**) Choice and Older Adults' Evening Activity Distributions; (**2**) TChoice and Temporal Activity Distribution of Older

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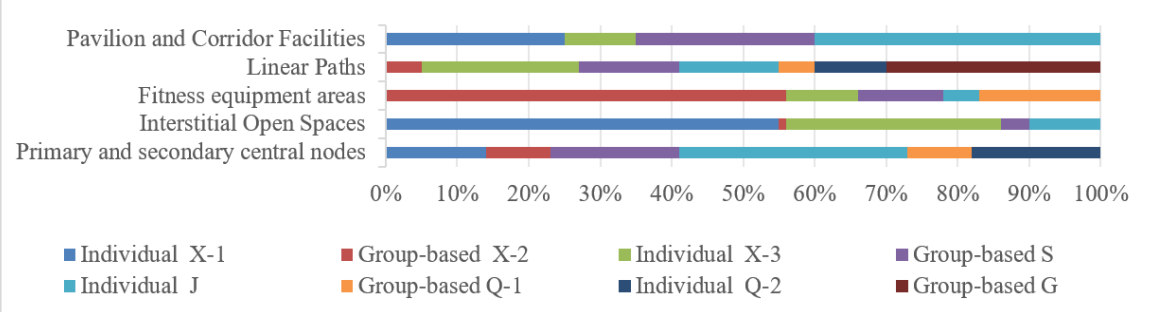
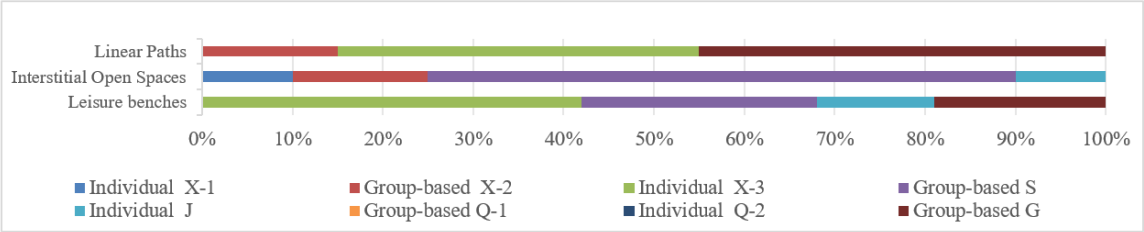
Adults - Fuel Community; (**a**) Choice and Older Adults' Morning Activity Distribution; (**b**) Choice and Older Adults' Afternoon Activity Distribution; (**c**) Choice and Older Adults' Evening Activity Distributions.



	Primary and secondary central nodes	Interstitial Open Spaces	Fitness equipment areas	Linear Paths	Pavilion and Corridor Facilities
Individual X-1	14%	55%	0	0	25%
Group-based X-2	9%	1%	56%	5%	0
Individual X-3	0	30%	10%	22%	10%
Group-based S	18%	4%	12%	14%	25%
Individual J	32%	10%	5%	14%	40%
Group-based Q-1	9%	0	17%	5%	0
Individual Q-2	18%	0	0	10%	0
Group-based G	0	0	0	30%	0

Figure 15. Proportion of Different Behavioral Levels Among Older Adults in Railway Dadongmen Community.



	Leisure benches	Interstitial open spaces	Linear paths
Individual X-1	0	10%	0
Group-based X-2	0	15%	15%
Individual X-3	42%	0	40%
Group-based S	26%	65%	0
Individual J	13%	10%	0
Group-based Q-1	0	0	0
Individual Q-2	0	0	0
Group-based	19%	0	45%

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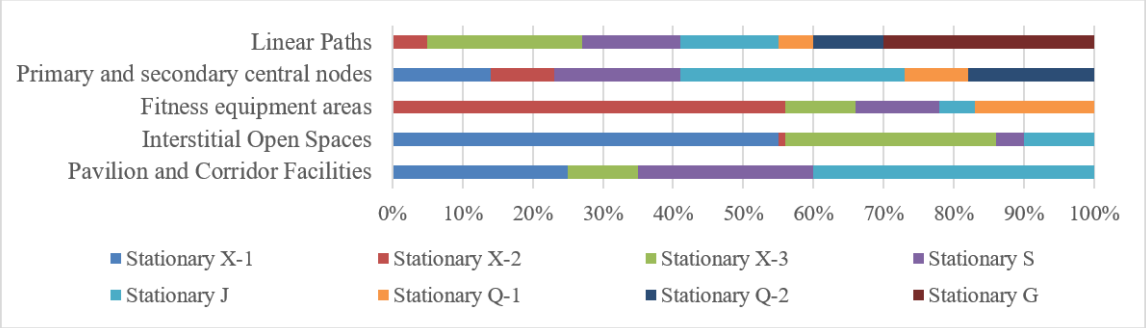
Figure 16. Proportion of Different Behavioral Levels Among Older Adults in Fuel Community.

(3) Areal Spaces

The richness of hierarchical types and visibility in areal spaces show a positive correlation with interaction quality. However, the survey reveals that, with the exception of squares, landscape quality does not demonstrate a complete positive correlation with interaction quality—that is, it shows little association with the frequency of behavioral transitions among older adults (Figures 8 and 17). From the perspective of behavioral factors, in areal spaces with low richness of hierarchical types, the lack of semi-open spatial layers significantly reduces the triggering of subject-object interactions. Nevertheless, due to visual decline among older adults and their higher demand for light exposure, open-type areal spaces—characterized by minimal obstructions and high visibility—facilitate more transitions from individual quiet observation to group-based leisure activities in spaces that include both enclosed and open types (Figures 18 and 19).From a sensory factor perspective, functional preferences in subject behavior are particularly evident, as older adults show a preference for squares with relatively better landscape quality (Figures 14, 20 and 21), while other well-landscaped interstitial spaces exert limited influence or attraction. In larger-scale communities, the lack of vegetation for shading greatly restricts the formation of peak usage periods for areal spaces in the afternoon, leading to reduced activity frequency during this time, though the impact on other periods remains minimal. In smaller-scale communities, limited outdoor space allocation and insufficient variation in spatial hierarchy result in older adults with mobility challenges often gathering in monotonous areal spaces, where activity types gradually shift from stationary to transitory. Furthermore, the rigid and inflexible layout of landscaping in areal spaces is reflected in the affordance evaluation tables, where sensory negative affordances and potential affordances show considerable room for improvement (Tables 4, 5). Compared to other factors, however, landscaping is not essential and holds significant potential affordance. When integrated with other elements, it can achieve a synergistic effect where "the whole is greater than the sum of its parts."



	Pavilion and Corridor Facilities	Interstitial Open Spaces	Fitness equipment areas	Primary and secondary central nodes	Linear Paths
Stationary X-1	25%	55%	0	14%	0
Stationary X-2	0	1%	56%	9%	5%
Transitorye X-3	10%	30%	10%	0	22%
Stationary S	25%	4%	12%	18%	14%

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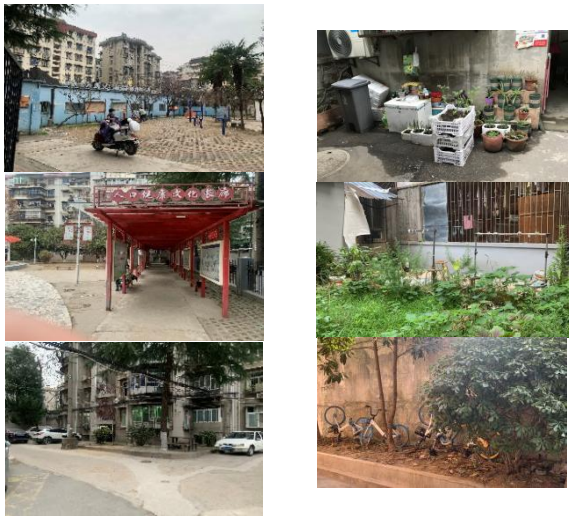
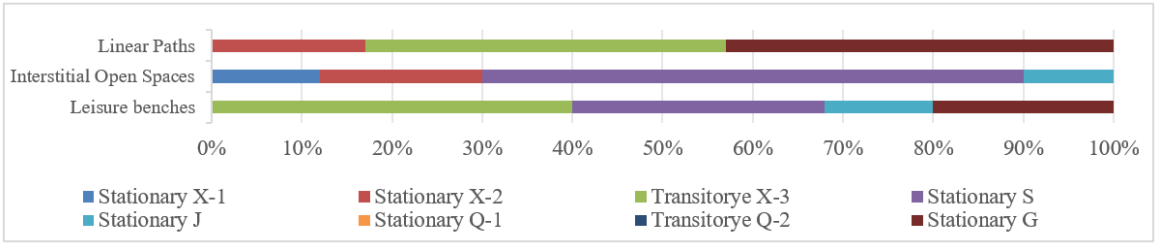
Stationary J	40%	10%	5%	32%	14%
Stationary Q-1	0	0	17%	9%	5%
Transitory Q-2	0	0	0	18%	10%
Stationary G	0	0	0	0	30%

Figure 18. Proportion of Different Behavioral Forms Among Older Adults in Railway Dadongmen Community.



(**a**) (**b**)

Figure 17. Landscape Environment Conditions in Residential Communities. (**a**) Landscape Environment Conditions in Railway Dadongmen Community; (**b**) Landscape Environment Conditions in Fuel Community.



	Leisure benches	Interstitial open spaces	Linear paths
Stationary X-1	0	12%	0
Stationary X-2	0	18%	17%
Transitorye X-3	40%	0	40%
Stationary S	28%	60%	0
Stationary J	12%	10%	0
Stationary Q-1	0	0	0
Transitory Q-2	0	0	0
Stationary G	20%	0	43%

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Figure 19. Proportion of Different Behavioral Forms Among Older Adults in Fuel Community.

Figure 20. Stopping Points and Greenery Distribution in Railway Dadongmen Community.

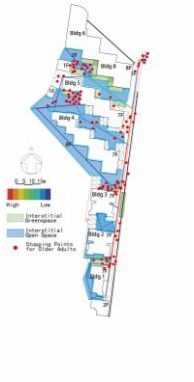

Figure 21. Stopping Points and Greenery Distribution in Fuel Community.

4. Interactive Renewal Strategies

For point-based spaces, integrating functional and emotional factors:(1) Incorporate group structures and rationally add new facilities. Installing age-friendly facilities, children's play equipment, or adding armrest-equipped seating along main community roads and near warmer-colored, larger areal spaces can effectively increase the frequency of behavioral transitions among older adults. Additionally, adding dedicated hanging facilities in exercise areas can not only address the functional alienation of rest facilities but also transform negative affordances into positive ones, reducing feedback effects in subject-object interactions. For other instances of spatial functional alienation (Figure 13), where the alienated functions actually meet needs, improve the accessibility of point-based spaces serving these functions—for example, by properly planning drying facilities and restoring the recreational function of easily accessible squares in connection with linear paths.(2) In the renovation of existing communities, for underutilized facilities, the following methods can enhance facility quality and promote human-environment interaction: First, consider functional upgrades to facilities, adding more interesting and practical features to attract more older users and improve facility quality. Second, improve pavement flatness around point-based spaces while enhancing the landscaping of some areas. Adding greenery combined with semi-open or enclosed landscapes, such as trimming plants into animal shapes to create themed green areas, can not only increase facility attractiveness, visibility, and accessibility but also effectively compensate for layout imbalances, alleviate negative emotions, and stimulate potential behavioral affordances.

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For linear spaces, integrating functional and behavioral factors:(1) In road planning: First, optimize branch road pedestrian routes using looped path systems to improve connectivity and enhance the accessibility of roads and isolated point-based spaces, creating routes that meet the diverse travel needs of older adults. Second, widen branch roads to improve visibility. Third, appropriately add leisure and viewing spaces. Plant diverse ornamental species with varying fragrances and colors along branch roads with low choice and through-movement values, simultaneously engaging multiple senses and promoting social interaction among older adults, thereby enhancing stationary behaviors like socializing and quiet observation in these linear spaces.(2) In existing community renovations, where only limited space expansion is possible in older communities, implement staggered vehicle management during peak hours to flexibly schedule usage times for different user groups on main roads, thereby enriching the diversity of behavioral transitions among older adults.

For areal spaces, integrating behavioral and sensory factors:(1) For single-layer areal spaces, design semi-open activity zones accommodating group socializing and parent-child activities. Optimize the layout of enclosed and open spatial areas according to lighting needs and requirements for individual quiet observation and group leisure activities, forming small-scale, dispersed recreational nodes based on the concept of pocket recreation spaces[21]. This approach improves visibility and hierarchical richness in areal spaces while promoting positive affordances in subject-object interactions and triggering behavioral exchanges among older adults.(2) In existing community renovations: First, considering the functional preferences of older adults, plan landscape types according to peak usage periods of areal spaces. Through questionnaire surveys and affordance evaluation, focus on meeting all-day usage needs for squares in larger communities by rationally planning tree and shrub planting areas and installing comfortable seating combined with art installations. For smaller communities, enhance the occurrence of stationary behaviors by adding diverse landscape elements like sculptures and strengthening fitness or social functions, creating pleasant and appealing places. Second, when renovating areal spaces with high potential affordance, introduce small to medium-sized therapeutic gardens following the green therapy approach of Danielle O. Winterbottom, closely integrating health restoration with outdoor spaces. This improves sensory affordance, transforms ornamental environments into empathetically interactive spaces for older adults, and converts potential affordances into positive ones.

5. Conclusions

This study applies an ecological interactive perspective and integrates the concept of affordance, adopting a top-down and bottom-up collaborative approach that combines forward-thinking design with reverse evaluation to refine the logic of interactive age-friendly optimization. By examining specific cases, a generalized framework for interactive renewal research is proposed, enabling the objective analysis and assessment of interaction processes. Based on the influence of various outdoor spatial interaction elements on the outdoor activities of older adults and the underlying reasons, more precise optimization strategies are formulated. This research provides empirical evaluation methods and novel design perspectives for establishing age-friendly outdoor spaces, while also offering a new viewpoint and methodological approach for the age-friendly optimization of residential outdoor spaces.

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References

1. Tan Shaohua, He Qixiao, Chen Luyao,et al. A Study on the Influence of Urban Park Environment on the Daily Interaction Activities of the Elderly. Chinese Landscape Architecture, 2020, 36(04): 44-48. DOI:10.19775/j.cla.2020.04.0044.
2. Tang Jie, Kang Xuan, Chen Rui, et al. Research on the Functional Space Model and Index System of Comprehensive Elderly Care Communities. Urban Planning Journal, 2015(02): 83-92. DOI:10.16361/j.upf.201502011.
3. Zhao Xiumin, Guo Weiwei, Shi Jianren. Aging Configuration Model of Community Outdoor Environment Elements Based on the Types of Daily Activities of the Elderly. Architectural Journal, 2017(02): 48-52.
4. Xie Bo, Zhou Jie. Research on Spatial Distribution Patterns and Development Trends of the Elderly in Large Cities: A Case Study of Beijing, Shanghai, Guangzhou, and Wuhan. Urban Planning Journal, 2013(05): 56-62.
5. Zhang Xinnan, Liu Kejia, Li Shilei. Research on Aging-Friendly Renewal of Urban Residential Areas Based on the Living Circle of the Elderly. New Architecture, 2017(01): 44-49.
6. Zhang Wenying, Feng Xiliang. The Significance of Inclusive Design for the Construction of Public Spaces in an Aging Society. Chinese Landscape Architecture, 2012, 28(10): 30-35.
7. Zhong Yaoqiong, Luo Zhenwei. Research on Optimization Strategies of Public Space in Old Communities Based on the Health Promotion of the Elderly. Chinese Landscape Architecture, 2021, 37(S2): 56-61. DOI:10.19775/j.cla.2021.S2.0056.
8. Lou Yuqing, Jin Hexiong, Zhang Li. A Sampling Survey and Analysis of Elderly Behavior in Urban Parks in Hangzhou in Spring. Chinese Landscape Architecture, 2019(03): 66-70.
9. Zhou Lan, Hu Jiafa, Liu Yongchun. The Influence of Outdoor Activity Space Landscape on the Health Perception of the Elderly in Hainan Communities. China Urban Forestry, 2022, 20(05): 42-47.
10. Di Feng, Pan Qiaoyu, Zhang Jianjian. Research on Activity Space Planning in Elderly Communities from the Perspective of Health. Beauty and Time (Urban Edition), 2022(02): 44-46.
11. Zhang Dongqing. Research on Satisfaction Evaluation of Outdoor Activity Spaces for the Elderly in Residential Areas in Changsha. Hunan University, 2019. Page 107.
12. Wang Hongyi. Research on Design Strategies for Institutional Elderly Care Buildings Based on the Interaction Between Space and Behavior. Dalian University of Technology; 2017.
13. He Lei. Value Analysis of the Application of Interaction Design in Residential Interior Space Design. Jushe, 2020(31): Page 81-82.
14. Wang Yao. Research on the Application of Interaction Design in Urban Public Spaces under the Background of Artificial Intelligence. Jushe, 2020(36): 69-72.
15. Watson D,Clark LA， Tellegen A. Developmentand validation of brief measures of positive and negative affect: the PANAS scales[J]. Journal ofPersonality and Social Psychology, 1988, 54(6):1063-1070.
16. Qiu Lin, Zheng Xue, Wang Yanfei. Revision of the Positive and Negative Affect Schedule (PANAS) [J]. Applied Psychology, 2008(3): 249-254.
17. Tan Shaohua, Peng Huiyun. Research on the Factors Influencing the Alleviation of Psychological Stress by Pocket Parks [J]. Chinese Landscape Architecture, 2016, 32(08): 65-70.
18. Ma Xuemei, Song Tianming, Wang Yi. Research on External Space Design from the Perspective of Affordability Theory [J]. Chinese Landscape Architecture, 2018, 34(10): 93-97.
19. Xie Bo, Wei Wei, Zhou Jie. Evaluation of Residential Space Environment and Aging Planning Strategies in Urban Aging Communities [J]. Planner, 2015, 31(11): 5-11+33.
20. Winifred Curran, Trina Hamilton Just Green Enough. Urban Development and Environmental Gentrification [M].2017.