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Analysis of Cross-Generational Co-Living Space Configuration in Residential Communities—Case Study in China and Italy Based on Space Syntax

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Abstract: In contemporary society, a notable trend of diminishing family sizes has led to an increasing number of elderly individuals living in solitude, often facing the end of life alone. This phenomenon underscores a critical challenge: addressing the pervasive loneliness experienced by many seniors. In response to this pressing issue, the concept of "cross-generational co-living" emerges as a potential solution. By exploring and implementing cross-generational co-living models, this research contributes to the development of more inclusive, supportive, and adaptable environments. The investigation involved an extensive field study and comprehensive data analysis of twenty-four instances of cross-generational co-living spaces in China and Italy. This analysis utilized space syntax as a fundamental theoretical framework, incorporating convex graphical topological relationship extraction and visibility graph analysis models. The outcomes of the study indicate that the configuration of cross-generational co-living spaces include spatial form, type, location, and the proportion of areas. Spaces arranged in a cluster form are most effective in promoting mutual communication. Spatial types and locations characterized by elevated integration values demonstrate a heightened potential for cross-generational communication. Space possessing a higher integration value typically correlates with a reduced ratio of area discreteness. These findings are instrumental in understanding how cultural and societal variances shape the design and utilization of cross-generational co-living spaces. Consequently, this study provides valuable guidelines for improving environments that are essential for advancing the principles of age-friendly design, which aims to enhance the quality of life for the elderly and foster a more harmonious and interconnected society across all generations.

Keywords: aging in communities; cross-generational co-living space; spatial configuration; age-friendly design; space syntax

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Citation: Zhang, D.; Setola, N.; Chen, Y. Analysis of Cross-Generational Co-Living Space Configuration in Residential Communities—Case Study in China and Italy Based on Space Syntax. *Buildings* **2024**, *14*, 346. https://doi.org/10.3390/buildings14020346

Academic Editors: Dafna Fisher-Gewirtzman and Efrat Blumenfeld Lieberthal

Received: 21 December 2023
Revised: 18 January 2024
Accepted: 22 January 2024
Published: 26 January 2024

1. Introduction

Since the 1970s, the phenomenon of population aging has emerged as a significant global challenge, initially manifesting in Europe and subsequently extending to the Americas and Asia [1]. Since the onset of the 21st century, advancements in medical science have considerably extended human life expectancy [2,3], leading to families encompassing a broader span of generations [4]. This demographic shift has amplified the importance of not only meeting the material needs of the elderly but also addressing their psychological and spiritual well-being [5]. Research indicates that older adults receiving social support and family care exhibit a lower propensity toward loneliness [6–10]. However, the trend of diminishing family sizes, characterized by a reduction in the number of individuals per generation and a shift towards more vertically extended family structures, poses new challenges [11]. In particular, the prevalent living arrangements where the elderly do not cohabit with their children [12] call for innovative approaches to mitigate their loneliness and fulfill their emotional needs, which is crucial in the context of promoting active aging.

To address this issue, alternative forms of housing, such as intergenerational shared living or co-housing, could offer solutions and provide older adults with more social contact [13–15]. The concept of "co-living" has been evolving to encompass age-friendly housing designs and the communal sharing of resources [16]. The scope of these investigations includes, but is not limited to, assessing residential settings, community infrastructure, and public spaces to ensure they are conducive to the health, well-being, and social engagement of older adults [17,18]. Nonetheless, when viewed through architecture and spatial design, there remains a discernible gap in sufficient exploration aimed at promoting intergenerational participation. This shortfall highlights the need for more focused research and innovative design strategies that specifically address the integration of diverse age groups within communal and residential spaces [17,19]. Thus, there exists an opportunity for further research in the domain of public space design, particularly in integrating cross-generational interactions within the living environments of aging communities.

1.1. The Concept of Cross-Generational Co-Living Space

This research builds upon existing paradigms, such as "co-living", "multi-generational housing", and "co-housing", pivoting specifically on the dynamics of cross-generational interactions independent of familial ties. Presently, the academic sphere lacks a universally accepted definition of "cross-generational co-living". Broadly, "cross-generational" pertains to the engagement of individuals from diverse age groups spanning two or more generations. The term "co-living" denotes a communal lifestyle, emphasizing the sharing of life experiences and resources, which fosters social capital and cultivates community bonds by integrating private living spaces with shared communal facilities [20–22].

Traditionally, in East Asian contexts, cross-generational co-living typically involves multiple generations cohabiting within blood-related familial structures [23]. In contrast, contemporary Western societies exhibit a trend towards cross-generational co-living arrangements that extend beyond familial connections [24]. For instance, the evolution of co-housing in Germany reflects a transition from traditional, large family structures to a multi-generational living framework that emphasizes intergenerational support and transcends the confines of blood relations [25]. In modern living environments, where community bonds are often weak and many elderly individuals experience solitude and loneliness, the concept of cross-generational co-living emerges as a critical solution. It offers the potential to foster spaces that encourage communication across generations, recreating living scenarios where neighbors coexist and support each other in a communal setting.

1.2. Background of Aging in Community in China and Italy

Residential communities have evolved beyond mere living spaces for the elderly [26]; they now function as dynamic environments that facilitate emotional engagement and social interaction [27]. This study focuses on a demographic sample of older adults and community centers in Shanghai, China, and Florence, Italy. Shanghai, as China's most populous metropolis, has witnessed urbanization trends that have diminished the centrality of familial ties. Florence, a medium-sized historical city in Italy, faces a demographic shift where young families are increasingly relocating, leaving a higher concentration of elderly residents. Interestingly, both cities report a similar proportion of the population over 65 years old, standing at 25.4% [28,29].

In terms of socio-cultural context and elder care, both China and Italy are characterized by predominantly family-centered societal norms [30,31] and family-based elderly care systems [32]. In the field of community elderly care, Chinese government statistics show that the number of community-based elderly care institutions grew from 19,000 in 2014 to 29,000 in 2017, while the number of community mutual aid facilities increased from 4000 to 8300 and the number of beds for elderly day care only increased from 187,500 to 338,500 [28]. Presently, China concentrates on infrastructure development [33] and locally based elderly care [34]. For example, Shanghai's elderly care service construction in 2020 included 729 elderly care institutions, 204 community care service institutions, 17 elderly care homes, 758 day care institutions, 1232 elderly service places, and 259 community service organizations. A representative project is the Good-neighbor Center on Fushun Road, Yangpu District, Shanghai, which serves the residents of Anshan New Village. It includes comprehensive functions, such as book reading, a tea room, an audio–visual room, a chess and card room, a children's play room, etc. It provides infrastructure services and social public place for the elderly. In Italy, there are three main different kinds of residential/institutional services: Nursing Homes (RA—Residenze Assistenziali), Protected Homes and Community-Based Settings (RS—Residenze Socio-Sanitarie), and Social Health Residential Structures (RSA—Residenze Sanitarie Assistenziali). With regard to the different typologies, in the period of 2001–2005, elderly patients in RSA increased from 98,940 to 132,052, whereas those housed in RA decreased from 98,565 to 84,040. In 2005, older people housed in residential facilities found placement in RSA in a proportion of 38.3%, with 33.1% in RS and 24.3% in RA (and 4.3% in other structures) [35]. The presence of comprehensive infrastructure and institutions in Italy has contributed to an increased emphasis on the spiritual and emotional well-being of the elderly population. Presently, Italy's emphasis is on sustainable designs for the elderly [36], co-living projects [37], and the development of health-oriented community initiatives [38]. A representative organization is Arci, a large cultural and social promotion association, which aims to help the elderly improve their quality of life in later years by organizing various cultural and recreational activities.

Field observations in Shanghai and Florence reveal distinct patterns in how the elderly engage with community centers. In Shanghai, the elderly's time is largely devoted to family activities [39], including childcare responsibilities. Elderly people in Florence typically maintain their pre-existing lifestyles, characterized by a higher degree of personal autonomy and private life [40]. These divergent lifestyles influence the utilization and functional requirements of community centers for the elderly in these cities. The architectural and spatial typologies in China and Italy also reflect their cultural diversity. Italian architecture often features cloister-style spaces and churches, while Chinese urban areas are more likely to include neighborhood centers and citizen service stations. Notably, Florence lacks the concept of gated residential communities as understood in the Chinese context and does not have community-specific facilities like canteens; the elderly usually go to restaurants and bars for meals.

Given these observations, the similarities and differences between Shanghai and Florence in terms of aging and community dynamics form a critical foundation for this study's field research and subsequent analysis. To focus the research, community activity centers and public spaces in representative elderly care institutions in both cities were selected for study. These venues are pivotal for observing cross-generational co-living behaviors and interactive communication, offering valuable insights into the diverse needs and preferences of elderly populations in different cultural settings. In interviews conducted with users and managers in these venues, it was found that different age groups focus on varying aspects. From a spatial configuration perspective, by statistically analyzing relevant keywords and categorizing similar terms, expressions like 'range of activities,' 'room size,' and 'good view' were classified under 'Spatial Form'; 'very comfortable' and 'good environment' were summarized as 'Comfort'; and 'variety of activities' and 'multiple functions' were grouped as 'Spatial Types'. It has been determined that Spatial Form is the most focused aspect in the current use and management of cross-generational co-living spaces, followed by Spatial Types and Comfort. The spatial configuration, encompassing form, types, and organization methods, reflects the most direct perceptions of users and significantly affects the effectiveness of communication. Therefore, it is essential to study in relation to cross-generational co-living spaces.

2. Methods

Spaces where cross-generational interactions can occur are mostly concentrated in elderly care service institutions, such as community centers, neighborhood activity centers, retirement homes for the elderly, and the public spaces integrated with urban life. After combining various factors, such as the movement of the elderly, supporting facilities, the degree of openness after the epidemic, and convenience of research, 13 cases in Shanghai and 11 cases in Florence were selected for field research. The research process is shown in Figure 1. For detailed information, see Appendix A Table A1.

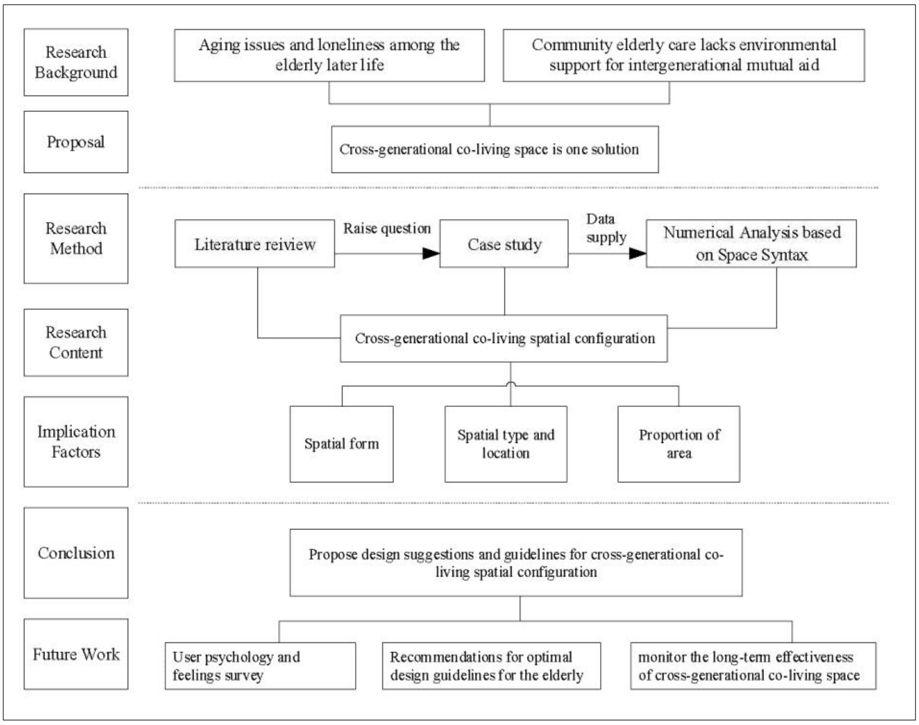


Figure 1. Research flowchart.

Cross-generational co-living space design aims to enhance interaction between the elderly and other age groups. Therefore, exploring spaces within indoor and outdoor environments that are conducive to interaction is particularly important. Generally speaking, in the same environment, spaces with higher connectivity to other areas are more likely to be chosen and used, thereby facilitating human interaction. From a mathematical perspective, this issue can be transformed into quantifying the degree of connection of a certain space with other spaces in the environment. In the field of architecture, the forms of space are endless. Solely studying spatial forms can lead to an endless abyss of graphical complexity. Therefore, the subject of spatial research must be the spatial organizational structure extracted through abstract methods. This involves the use of geometric graph theory methods [41]. After abstracting the space graphically, one can study the degree of spatial connectivity using topological methods in spatial connection relationships. In mathematics, topology is a discipline that studies topological spaces, focusing on properties within a space that remain constant under continuous change. Important topological properties include connectivity and compactness. Space syntax is the most widely applied method in architecture, based on graph theory and topology, to study the degree of spatial connectivity [42].

Space syntax theory applies principles of mathematical logic to quantify space and describe its composition using topological relationships. It studies how spaces connect and how these connections affect movement, social interaction, and the functionality of spaces. Therefore, in this paper, compared to other methods, space syntax enables the abstraction, comparison, and analysis of multiple complete spatial forms, assessing and evaluating the connectivity of spaces, and more closely relating these to human behavior. By quantifying spaces, the qualitative aspects of space are converted into quantitative data, allowing for empirical research on how spatial design influences human behavior, movement patterns, and interactions [43]. In the analysis of a cross-generational co-living space, space syntax theory aids in identifying how the arrangement and connectivity of community activity center spaces can promote or inhibit interactions between different age groups, offering a methodological approach to quantifying and understanding the potential for social activities within shared spaces [44].

The reasons for choosing space syntax theory can be briefly stated as follows. 1. Space syntax uses the principles of mathematical logic to quantify space and describes the spatial structure with topological relationships to study how spaces are connected and how this connection affects movement, social interaction, and the functionality of the space [41,42]. It can help identify how the layout and connectivity of a community activity center space promote or inhibit interaction between different age groups, and it provides a methodological approach to understand the potential of social activities in shared spaces [43,44]; 2. It shows how an empirical assessment of collective behavior and social integration can influence space design by mapping and analyzing people's flow paths and spatial nodes. Users' movement and interaction patterns can be predicted [45,46]; 3. The robustness of the theory enables it to transform complex spatial arrangements into understandable data, allowing researchers to apply its principles to optimize shared spaces [47–49]. This optimization can increase cross-generational communication by promoting inclusive design, ensuring equitable access to shared resources, and fostering a sense of unity among residents of all ages.

Comparing the theoretical models and parameters commonly used in architecture using space syntax theory, the selections in this article to measure the relationships between cross-generational co-living space structures are shown in Table 1 below.

Table 1. Models and parameters of space syntax theory.

Items	**Common Models and Parameters of Space Syntax**				**Cross-Generational Co-Living Space Application Models and Parameters**	
Models	Convexmap	Visual graph analysis (VGA)	Axial Line	Segment	Convexmap	VGA
Applied fields	Indoor space planning, functional space configuration, and architectural streamline analysis	Monitoring analysis, space utilization research, emergency evacuation modeling	Urban planning, building layout analysis, pedestrian movement prediction	Street network analysis, transportation planning, urban walkability research	Interior space planning, circulation analysis, functional distribution, social interaction, accessibility and inclusion	Visual interaction, spatial navigation, security monitoring, space utilization
Parameters	connectivity, control value, depth value, integration, intelligibility				integration, visual integration	

A cross-generational co-living space, characterized by distinct indoor and outdoor architectural boundaries, can utilize convexmaps and visibility graph analysis as computational models. A convexmap involves extracting topological relationships of spaces to study their forms and interrelationships. Convexmap analysis is one of the fundamental tools for analyzing architectural layouts. This study employs JASS v1 and DepthmapX 0.8 software to establish topological relationships and obtain visual representations and values for each functional space (see Appendix A Table A2). JASS is aimed at convex space analysis by converting spaces and their connections into points and lines, drawing networks, and transforming graphs into rational maps presented in various forms, such as deep branching trees, shallow ring clusters, etc. DepthmapX enables the generation of spatial element maps of buildings by connecting them through relationships (visibility, crossing, or adjacency) and analyzing the resulting networks.

Integration value, a computation method improved by P. Steadman, is normalized using relative asymmetry (RA), calculated as RA = 2 (MD − 1)/(n − 2), where 'n' is the total number of nodes. To correlate positively with practical significance, RA is inverted to denote the integration value. Further normalization is achieved using Relative Integration Value (RRA) to compare spatial systems of different sizes, calculated as RRA = RA/Dn. Corresponding to total and local depth values, there are global and local integration values. Global integration reflects the tightness of connections among all nodes in the system, suitable for small-scale buildings and interior spaces. In contrast, local integration measures the closeness of connections between a node and its immediate vicinity, typically calculated within three or ten steps, termed 'radius-3 integration' or 'radius-10 integration', which is more suitable for urban-scale computations.

$$\mathrm{MD} = \mathrm{TD}/(\mathrm{k} - 1) \tag{1}$$

$$\mathrm{RA} = 2\frac{\mathrm{MD} - 1}{\mathrm{k} - 2} \tag{2}$$

$$\text{RA of Diamond} = \frac{\mathrm{n}\left\{\log_2\left(\frac{\mathrm{n}}{3}\right) - 1\right\} + 1}{\frac{(\mathrm{n}-1)(\mathrm{n}-2)}{2}} \tag{3}$$

$$\text{Relativized RA} = \frac{\mathrm{RA}}{\text{RA of Diamond}} \tag{4}$$

$$\mathrm{Integration(HH)} = \frac{1}{\mathrm{RRA}} \tag{5}$$

The meanings of some parameters involved in the formula are as follows:

MD: Mean Depth.

TD: Total Depth for actual node.

k: Number of nodes.

Visibility graph analysis dissects the spatial plane into a sufficient grid, with each grid as a study element. Elements within visible range are quantified, thus enabling numerical analysis. The visibility analysis method, evident in the overall spatial system diagram, is more precise and numerically oriented. For the refined spatial grid, variations in color intensity indicate the convenience of different units within the overall spatial system. Bill Hillier's research suggests that spaces with higher integration (more red) are more conducive to static behaviors, such as staying, resting, and conversing, thus identifying the most suitable locations in a spatial system for people to gather and interact. Higher visual integration values indicate areas more likely to be seen and actively used by people. Visual Integration (VI), discussed in visibility analysis, is derived from Visual Step Depth (VSD) and follows the same algorithm as topological integration. It represents the number of turns required from a specific element to another, with this value recorded at the starting point. After exhausting all possibilities, the total number of turns is summed and recorded at the starting point, denoting the Total Visual Step Depth (TVSD). With the TVSD calculated, RA, RRA, and eventually the integration value are derived, indicating the visual integration value of the element. Once calculated for the entire system, each element is marked with a visual integration value, allowing software to generate a color-coded feature map. Warmer elements indicate higher visual integration values.

Visual integration represents the global visual depth, excluding topological influences. Higher visual integration values indicate places easily visible with fewer turns from any location in the system, attracting more visual attention. Conversely, lower visual integration values are less likely to attract attention. This model facilitates the analysis of architectural spaces to identify areas suitable for direct or indirect visual communication among all age groups.

3. Results

3.1. Data Analysis

The integration parameters of the convex graphics are integrated and arranged in descending order according to the average value. The calculation results are shown in Table 2. In order to facilitate comparison and analysis of the integration degree of different samples, it is planned to use the maximum and minimum values of all samples as a unified standard to recolor the scales of all samples. Due to the discrete nature of the data, when the extreme values in individual samples are used as the upper and lower limits of the scale, it will lead to poor differentiation of sample color blocks, which is not conducive to reading or data analysis. After a large number of experiments, it was found that the maximum discreteness of samples FIQ501 and SHBS01 has the greatest impact on the discrimination of data color blocks. Therefore, this study plans to use the maximum values of these two samples and extreme values of the remaining samples as the upper and lower limits of the scale.

Table 2. Numerical statistics of integration degree of convex graphics.

Samples	Integration HH		
	MIN	**MEAN**	**MAX**
FIQ501	0.773	1.781	4.897
SHBS01	0.978	1.67	5.625
SHHK03	0.91	1.509	3.439
FIQ401	0.771	1.41	2.601
SHPD01	0.802	1.409	2.979
FIQ202	0.833	1.359	2.48
FIQ201	0.659	1.263	2.396
FIQ503	0.836	1.263	2.661
FIQ301	0.634	1.243	2.957
FIQ502	0.583	1.224	2.005
SHYP05	0.643	1.16	2.385
SHHK02	0.579	1.106	2.2
Mean of mean integration HH		1.104	
SHYP04	0.551	1.009	2.273
SHHP01	0.563	1.008	1.93
SHYP01	0.62	0.99	1.606
FIQ505	0.566	0.965	1.48
SHYP02	0.58	0.96	1.689
SHBS02	0.737	0.955	1.659
SHJA01	0.523	0.954	1.811
SHHK01	0.63	0.938	1.599
FIQ103	0.533	0.907	1.37
SHYP03	0.549	0.905	1.452
FIQ102	0.556	0.871	1.45
FIQ101	0.417	0.869	1.489

As for visual graphics, all planes of the samples are refined with the scale of a 550 mm grid simulating a single flow of people. The positional relationship of people in the space is quantified in this way, and the degree of visual communication between users in the space can be explored. Consistent with the processing method of the integration value of convex graphics, the integration parameter values of all sample sight diagrams are arranged in descending order according to the average value. The results are shown in Table 3. Consistent with data analysis of the convexmap, after a large number of experiments, it was found that the maximum discreteness of samples FIQ201, FIQ401, and SHYP04 has the greatest impact on the discrimination of data color blocks. Therefore, this study plans to use the maximum values of these three samples and the extreme values of the remaining samples as the scale. After collation and analysis, the visual results are shown in Appendix A Table A3.

Table 3. Numerical statistics of VGA integration degree.

Samples	Visual Integration HH		
	MIN	MEAN	MAX
FIQ201	4.436	17.803	35.483
FIQ401	3.317	14.982	26.387
SHYP04	3.438	11.454	20.487
FIQ202	2.885	10.807	17.311
FIQ502	2.65	10.267	15.562
SHPD01	3.256	9.053	17.384
FIQ503	3.212	8.31	14.002
FIQ301	3.035	8.293	17.368
Mean of mean visual integration HH		7.074	
SHHK02	3.565	7.062	13.133
SHYP01	2.563	6.193	11.595
FIQ505	3.123	5.924	10.711
SHHK01	2.274	5.853	10.509
SHBS01	3.132	5.723	10.559
SHJA01	1.812	5.645	9.381
FIQ102	1.864	5.47	8.674
SHYP02	2.555	5.332	8.937
SHBS02	3.637	5.308	9.911
SHYP03	2.194	4.764	9.133
SHHP01	1.767	4.339	7.651
FIQ501	2.582	4.323	8
SHYP05	2.088	4.322	8.069
FIQ103	1.715	4.103	5.862
SHHK03	2.472	4.064	7.729
FIQ101	0.695	1.175	1.742

3.2. Spatial Forms

The spatial form and the area ratio will affect the organizational structure and the configuration of the space. At the same time, the function and type of space are also important aspects that affect the use of a certain space by generations. According to Francis D. K. Ching's [50] classification of spatial order in architectural forms, there are five spatial forms and organizational methods: concentrated form, linear form, radial form, cluster form, and grid form. Except for the grid form, all other spatial forms appear in the cross-generational co-living cases. Some samples comprise a combination of multiple spatial forms. Therefore, when classifying, the spatial form is mainly based on the core space where cross-generational co-living interactions can occur. The linear form is divided into two categories, bilateral and one-lateral, due to the location of the corridor. According to the two integration values corresponding to the convex figure and VGA models, the sorting results of five spatial forms of cross-generational co-living space are shown in Tables 4 and 5 below.

Table 4. Integration values of samples.

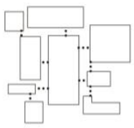
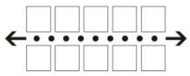
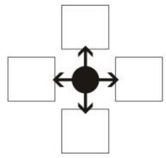
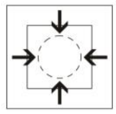
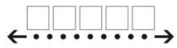
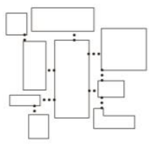
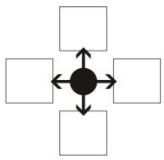
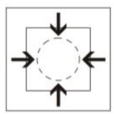
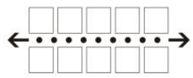
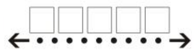
Cluster Form	Bilateral Linear Form	Radial Form	Centralized Form	One-Lateral Linear Form
				
Samples	Samples	Samples	Samples	Samples
FIQ201/FIQ401/FIQ503/SHYP01/SHYP04/SHPD01	FIQ501/FIQ505/SHYP05/SHJA01/SHHK02/SHHP01/SHBS01	FIQ301/SHHK01	FIQ101/FIQ102/FIQ103/FIQ202/FIQ502/SHHK03	SHYP02/SHYP03/SHBS02
Mean of integration mean value	Mean of integration mean value	Mean of integration mean value	Mean of integration mean value	Mean of integration mean value
1.224	1.235	1.091	1.123	0.94
Median of integration mean value	Median of integration mean value	Median of integration mean value	Median of integration mean value	Median of integration mean value
1.263	1.106	1.091	1.066	0.955

Table 5. Visual integration values of samples.

Cluster Form	Radial Form	Centralized Form	Bilateral Linear Form	One-Lateral Linear Form
				
Samples	Samples	Samples	Samples	Samples
FIQ201/FIQ401/FIQ503/SHYP01/SHYP04/SHPD01	FIQ301/SHHK01	FIQ101/FIQ102/FIQ103/FIQ202/FIQ502/SHHK03	FIQ501/FIQ505/SHYP05/SHJA01/SHHK02/SHHP01/SHBS01	SHYP02/SHYP03/SHBS02
Mean of integration mean value	Mean of integration mean value	Mean of integration mean value	Mean of integration mean value	Mean of integration mean value
11.299	7.073	5.981	5.334	5.135
Median of integration mean value	Median of integration mean value	Median of integration mean value	Median of integration mean value	Median of integration mean value
10.254	7.073	5.645	5.308	4.787

The rank of the mean integration of convex spatial forms is: bilateral linear form > cluster form > centralized form > radial form > one-lateral linear form. The rank of the median is: cluster form > bilateral linear form > radial form > centralized form > one-lateral linear form. Overall, in terms of integration, the cluster form is the spatial form with the highest average integration value, followed by the bilateral linear form, radial form, and centralized form, while the one-lateral linear form is the spatial form with the lower average integration value.

By analyzing and comparing the sample cases in Shanghai and Florence, we can see that:

- The cluster form samples all have indoor–outdoor transitional grey spaces at the main entrance, which are all spatial combinations around the entry (courtyard, grey space);
- The bilateral linear form samples are all closed corridors, and the layouts of the rooms on both sides are similar to the layout of an office building with high work efficiency, so it can be used in conjunction with more functional spaces. The Florence cases have certain functions, such as classrooms, theaters, and office buildings, and the Shanghai cases have various functions, such as exhibition halls, community shops, and cinemas;
- The radial form samples all have a dominant space with the open space as the center. In the Florence cases, the BAR at the corner is the central connection, and in the Shanghai cases, the lobby is the central connection;
- The centralized form samples are all enclosed courtyard/atrium cases. Historically converted buildings in Florence are concentrated specimens;
- The one-sided linear space form only appears in the Shanghai case, and they are all connected by outdoor corridors. There are relatively few activity centers with one-side connected groups in the Florentine community.

The rank of the mean integration of visual graphics spatial forms is: cluster form > radial form > centralized form > bilateral linear form > one-lateral linear form, and the median rank is same. Overall, in terms of visual integration, clustered and radial spatial forms have higher mean visual integration, followed by the centralized form. The bilateral linear form is close to one-lateral linear form. The ranking results of the integration value of the convexmap are a little bit different. The clustered form is the highest-ranking spatial form of both models. The comparison of the convexmap integration values of the radial form, bilateral linear form, and centralized form is similar, while in the comparison of visual integration value, the radial form ranks much higher than the bilateral linear form, the centralized form and the bilateral linear form are similar, and the one-lateral linear form ranks lower in both. Corresponding to the practical significance of architectural space, the difficulty of direct communication and visual communication in the five types of space forms is shown in Table 6 below.

Table 6. The degree of difficulty of direct and visual communication among the five types of space forms.

Spatial Forms Degree of Difficulty: 1 (Easy)–4 (Difficulty) Communicating Ways	**Cluster Form**	**Radial Form**	**Centralized Form**	**Bilateral Linear Form**	**One-Lateral Linear Form**
Direct communication	1	2	3	2	4
Visual communication	1	2	2	3	4

3.3. Spatial Types

According to the ranking results of the unified scale of the mean integrated value, it can be seen that:

FIQ501 > SHBS01 > SHHK03 > FIQ401 > SHPD01 > FIQ202 > FIQ201 > FIQ503 > FIQ301 > FIQ502 > SHYP05 > SHHK02 > Average > SHYP04 > SHHP01 > SHYP01 > FIQ505 > SHYP02 > SHBS02 > SHJA01 > SHHK01 > FIQ103 > SHYP03 > FIQ102 > FIQ101.

The first three samples with the highest integration values are all closed-corridor-type planes, that is, bilateral linear spatial forms. The integration value only considers the relationship between abstract spaces and excludes other factors, such as the functional settings of the actual space, people's usage and stay, etc. Therefore, the efficiency is the only standard of evaluation. The corridor connects the rooms on both sides without much depth, so it is the location with the best connectivity and highest efficiency. This type of transportation space has the highest integration value. Starting from the fourth and fifth samples, the locations with higher integration are spaces with mixed functions, such as foyers, halls, multi-functional rooms, etc. Among the lower-than-average samples, FIQ101′s two courtyards provide a good interactive space for residents and urban pedestrians living here, but the former introverted and closed historical prison building was renovated, so the connectivity of the entire building is poor; FIQ102 has a community canteen close to the east courtyard, which provides a good communication place for the elderly and students from nearby colleges. However, the space itself is located at the end of the building, far away from the entrance and the main courtyard. Also, it is solely open to residents of this nursing home and students of the adjacent School of Architecture, exhibiting limited public access and openness. The children's play area of SHYP01 has good visual communication with the entrance grey space and outdoor play area, but there are no long corridors connecting all of the rooms in this case, and the functional areas are spread out over two floors, so SHYP01 has a low integration value.

After extracting and classifying the spatial types of all samples based on functions and usage, the average integration value of each spatial type is calculated to determine which type has better connectivity and communicability. Judging from the visualization results of convex graphics, the spatial types with the highest integration value in each sample are shown in Table 7 below.

Table 7. The most integrated spatial types.

Spatial Types	Corresponding Sample (Highest Integration Value)	Mean Integration Value
Corridor (traffic space)	FIQ101(1.62)/FIQ401(2.6)/FIQ501(4.89)/ FIQ505(1.48)/SHYP01(1.61)/SHYP04(2.27)/ SHYP05(2.38)/SHHK01(1.6)/SHHK02(2.2)/ SHHK03(3.44)/SHHP01(1.93)/ SHPD01(2.98)/SHBS01(5.63)	2.654
Foyer (traffic space)	FIQ503(2.66)/SHHK02(2.2)	2.43
Multi-functional hall (functional space)	FIQ201(2.4)	2.4
BAR (functional space)	FIQ301(2.96)/SHJA01(1.81)	2.385
Entrance plaza (outdoor space)	FIQ202(2.48)/SHBS02(1.66)	2.07
Entrance grey space (transition space)	FIQ401(2.6)/SHYP02(1.69)/SHYP03(1.45)	1.913
Cloister (transitional space)	FIQ102(1.42)/FIQ502(2.01)	1.715
Courtyard (transitional space)	FIQ103(1.33)	1.33

Corridors, foyers, multi-purpose halls, BARs, entrance plazas, entrance grey spaces, cloisters, and courtyards are the most integrated space types, that is, the locations with the best spatial connections. Among them, multi-functional halls, cloisters, and courtyards are the most integrated space types that only appear in the cases in Florence. The other space types are found in both Shanghai and Florence. According to the field observation, the comparative results of the spatial design features with the highest integration from the two places are shown in Table 8 below.

3.4. Spatial Position

According to the ranking results of the unified scale of mean visual integrated value, it can be seen that:

FIQ201 > FIQ401 > SHYP04 > FIQ202 > FIQ502 > SHPD01 > FIQ503 > FIQ301 > Average > SHHK02 > SHYP01 > FIQ505 > SHHK01 > SHBS01 > SHJA01 > FIQ102 > SHYP02 > SHBS02 > SHYP03 > SHHP01 > FIQ501 > SHYP05 > FIQ103 > SHHK03 > FIQ101.

Table 8. Comparison of design features of the most integrated cross-generational co-living spatial types in the two cities.

Compare Spatial Types	Similarities	Differences	
		Shanghai	Florence
Corridor	• Set rest seats; • Bright and warm colors; • Open interface; • Posters (columns) display information; • Accessibility.	• Wall displays handicrafts, traditional culture, and community activities; • Green plants; • Multi-functional spaces; • Linear markings on walls, ceilings, and floors are clear and dynamic and integrate well with lighting fixtures; • Multimedia presentation.	• Continue historical materials and features.
Foyer	• Set up rest areas; • Set up a community cultural and historical exhibition area (wall); • Versatile mixing.	• Through the line of sight to the upper functional space; • Set-up children's play items.	• Colorful; • Placed green plants.
BAR	• Open space; • Colorful.	• Placed green plants; • Multi-functions; • Diverse furniture.	• The dining table can be set up flexibly with columns; • Diverse lighting levels.
Entrance plaza	• Natural greening; • Accessible ramp.	• Linear markings are clear and dynamic; • Wall murals; • Natural greenery.	• Set-up rest areas; • Axis landscape.
Entrance gray space	• Accessible ramps; • Natural greening; • The interface is open and transparent; • Set up seating areas.	• Ground material changes; • Window panels and pillars display community activities; • Sufficient sunshine.	• Diverse furniture styles.

Compared with the convex graphic integration value that corresponds to space usage efficiency, the visual integration value reflects viewing a larger spatial range, so the location with a high visual integration value is generally at the junction of large spaces. Spatial locations ranked higher have window openings in open spaces, joints of large spaces, open spaces in the center, entrance halls, etc. Ranked lower are the junctions between closed corridors and large space doors and window openings, long corridors, etc. Therefore, having a long corridor is not conducive to visual communication.

Judging from the visual results, the spatial location with the highest visual integration value in each sample is shown in Table 9 below.

Table 9. Spatial location with the highest visual integration value.

Spatial Location	Corresponding Samples (Highest Visual Integration Value)	Mean Value of Visual Integration
Hall/Plaza Center	SHYP04(11.454)/FIQ202(10.807)	11.13
Patio edge	FIQ401(14.982)/FIQ505(5.924)/FIQ102(5.47)	8.792
The junction between the foyer and hall/entrance/corridor	FIQ503(8.31)/SHPD01(9.053)/ SHHK02(7.062)/SHYP01(6.193)	7.655
Multiple open space connections (window openings, corridors)	FIQ201(17.803)/FIQ502(10.267)/FIQ301(8.293)/ SHHK01(5.853)/SHHJA01(5.645)/FIQ102(5.47)/ FIQ103(4.103)/FIQ101(1.175)	7.326
Corridor and large space/room connection	SHBS01(5.723)/SHYP02(5.332)/SHBS02(5.308)/ SHYP05(4.322)/SHHP01(4.339)	5.005
Junction of long corridors	SHYP03(4.764)/FIQ501(4.323)/SHHK03(4.064)	4.384

Based on the results of field observation, the design characteristics of various spatial locations with the best visual communication are summarized as follows:

- Hall/square center: set up a rest area, diversified functions, and flexible partitions;
- Patio edge: open the boundary with public spaces, such as the main functional rooms or foyers, to create transparency;
- The junction between the foyer and the lobby/entrance/corridor: create an open interface, set up a clear identification system, and have diversified functions;
- Multiple open space connections (window openings, corridors): increase the area of the connections, diversify the connection methods, and set up rest areas;
- The connection between the corridor and the large space/room: appropriately enlarge the node area, set up a rich and interesting interface, and create an open interface;
- At the junction of long corridors: set up a rest area, enlarge the node area, and set up a clear sign system.

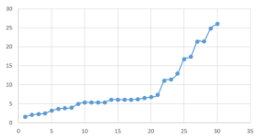
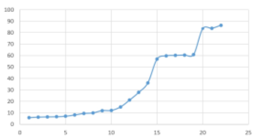
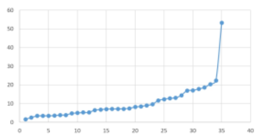
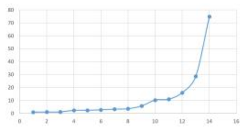
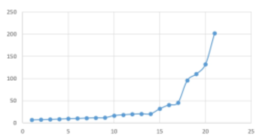
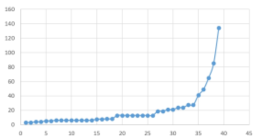
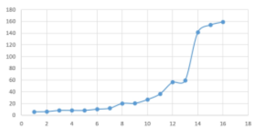
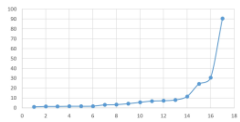
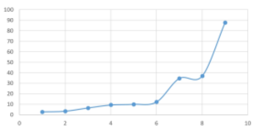
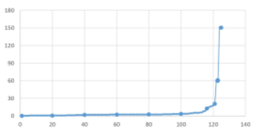
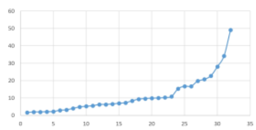
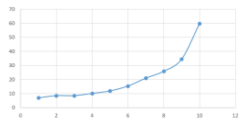
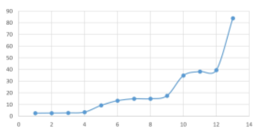
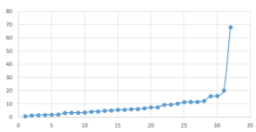
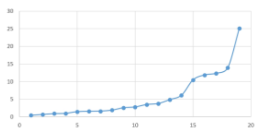
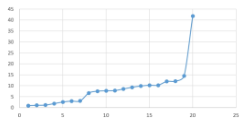
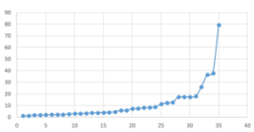
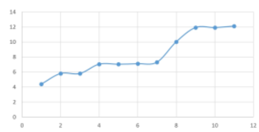
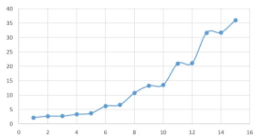
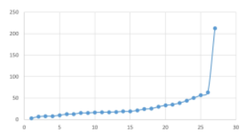
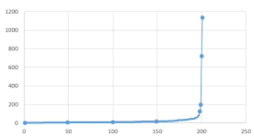
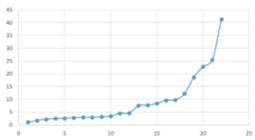
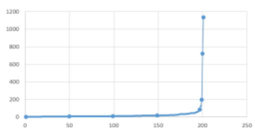
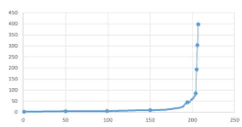
3.5. Area Proportion

In addition to spatial form, spatial type, and location, the impact of connectivity can also be analyzed through the spatial area proportion. From the previous comparison of the calculation methods of integration and visual integration values, it can be seen that compared with using a grid to quantify the visual integration of a plane, the integration analysis using convex graphics as a model makes it easier to quantify the spatial area. The analysis of the spatial area proportion in this section is based on the ranking of convex graphic integration values.

From the spatial form integration ranking, it can be seen that the mean integration value of the sample data corresponding to the cluster form, bilateral linear form, and radial form is higher. Ranking by spatial type, it can be seen that the bilateral linear form and the cluster form are at the forefront. The area scales of these two spatial forms are relatively small, which can be understood as low discreteness. Therefore, the convexmap areas of all samples are statistically calculated in one-to-one correspondence, and the area discreteness of each case is compared. The resulting relationship is shown in Table 10 below. The closer the sizes of the various spaces in the building, the gentler the slope of the line graph; the greater the size difference between the various spaces in the building, the steeper the slope of the line graph. Intuitively, as the average integration value decreases, the slope of the line graph becomes steeper, indicating that the size difference of each space in the building is increasing. This implies that spaces with enhanced integration—a measure of spatial connectivity and accessibility—tend to exhibit a more uniform distribution of area within their configuration. This uniformity in spatial distribution is instrumental in facilitating movement and interaction within the space, thereby contributing to its overall functional efficacy and social dynamics.

Except for a few cases (FIQ502, SHBS02, and SHJA01), due to various factors, such as a small number of spaces and measurement errors, most of the samples are consistent with the following standards: the lower the area dispersion (the smaller the difference in size of each spatial scale), the higher the spatial integration value, and the better the connectivity. Practically, except for auxiliary and service rooms, the closer the areas of each space in the building, the better the effect of cross-generational communication. It can also be seen from the curve relationship chart that the discreteness of the Shanghai sample is lower than that of the Florence sample. This is because many sample cases in Florence are historical building renovations, which are related to the structure and plan form of the original building itself.

Table 10. Comparison of area discreteness.

FIQ501	SHBS01	SHHK03	FIQ401
			
SHPD01	FIQ202	FIQ201	FIQ503
			
FIQ301	FIQ502	SHYP05	SHHK02
			
SHYP04	SHHP01	SHYP01	FIQ505
			
SHYP02	SHBS02	SHJA01	SHHK01
			
FIQ103	SHYP03	FIQ102	FIQ101
			

4. Discussion

A cross-generational co-living space is a container that accommodates people with different social and cultural backgrounds and living habits. Being closely connected with society and obtaining certain emotional feedback are basic life demands of people of all ages. This is often ignored by designers when they shape public spaces [51]. And while neighborhoods should be designed in a way that encourages people of all ages to leave their house every day to promote physical activity and social interaction, this may be encouraged in very different ways in different countries [52]. Starting from the spatial structure and configuration, quantitatively interpreting the spatial layout can allow for studying the relationship between cross-generational behavior and architectural space from a more objective and in-depth perspective.

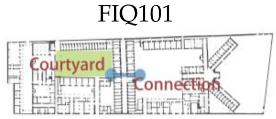
A comparative analysis of five spatial forms is presented (see Table 11). Combining field observations and interviews, it is evident that the cluster form, exemplified by case study FIQ503, attracts users of all ages. Elderly individuals enjoy staying here during the day for coffee, card games, and casual conversations; young people attend classes on weekends and play table tennis after dinner; children visit with their families for reading and playing. The fully open foyer accommodates various functions, such as a bar, reading area, cultural displays, and chess, enabling multi-generational users to meet their diverse needs and promoting shared use. This space has the highest level of integration, making it the area with the best interaction and communication. The cluster layout lacks long corridors, resulting in easily accessible functional rooms, smaller room dimensions, and spaces adaptable to diverse and flexible uses. The connected corridor entrance has the highest visual integration value, and, in practice, it serves as an open space connecting the interior and exterior, where many people enjoy coffee and conversations. The radial form, represented by case SHHK01, consists of an open central hall radiating outwardly to connect public spaces and various functional rooms. The hall, having the highest integration value, is a common spot for people of all ages to rest, relax, and wait. The junction of the hall and the open café is the point of highest visual integration and the most intense site for indirect communication. The centralized form, represented by FIQ101, a former historical prison transformed into a multi-generational community, is inwardly oriented, focusing sight and social interactions on the central courtyard. The west courtyard is the area of highest integration value. In practice, the courtyard is mainly used by residents and employees working in the ground-floor offices, galleries, and bars. Due to its closed inward form, it attracts fewer visitors not working or living there, except during events, resulting in average multi-generational interaction. The connection point of the east and west courtyards is a high-traffic area but sees less lingering and conversation. The bilateral linear form, exemplified by FIQ501, typically features a corridor with rooms. The main corridor and the bar at the entrance are the most frequented spots for multi-generational interaction. The corridor, being the most efficient space connector, also has the highest integration value. Observations show that while the exhibition walls along the corridor encourage some lingering, the lack of seating and multi-functional features means it primarily serves as a thoroughfare with limited social interaction. The point of highest visual integration is the junction of the entrance hall and the main corridor, which remains a part of the traffic flow with a broader view but limited actual communication compared to the bar on the west side. The one-lateral linear form, represented by SHYP03, connects important functional rooms through a gray space at the entrance plaza, the area with the highest integration value. However, this also leads to a highly functional orientation with poor internal connectivity. People visiting this space have specific target rooms in mind and rarely interact in the entrance plaza. The spot with the highest visual integration value is at the junction of the entrance plaza and the activity center, where a few elderly individuals rest and soak in the sun.

The quantitative calculations of the spatial forms, types, locations, and area ratio closely match the results of the actual research. The cluster form provides a homogenous spatial experience and fosters diverse interactive communications; the radial form centers around an open space that becomes a concentrated area for communication; the centralized form tends to gather long-term users with limited openness to the city; the bilateral linear form, with its highly efficient corridor spaces, needs to transcend its singular transport function and incorporate multi-functional features to enable interactions; and the one-lateral linear form, being target-oriented, is the least efficient in promoting interactions.

4.1. Implications of Findings for Cross-Generational Co-Living Spaces

As a practical implication, this study offers insights and guidance for interior designers, architects, and urban planners involved in creating spaces conducive to cross-generational co-living. The research delineates key factors influencing the spatial organization of such environments, including spatial form, type, location, and area proportion. Architects can utilize these insights to design more effective cross-generational living spaces that cater to diverse needs. Urban planners can integrate these concepts into broader city planning to enhance community integration and social cohesion. For policymakers, the research findings can inform policies that support the creation and management of these spaces, addressing demographic trends and social welfare goals.

Table 11. Comparison of different spatial configurations.

Spatial Forms	Representative Cases *	Interactive Spatial Type	Interactive Spatial Position
Cluster form	FIQ503 		
Radial form	SHHK01 		
Centralized form	FIQ101 		
Bilateral linear form	FIQ501 		
One-lateral linear form	SHYP03 		

* Green parts in plans represent space types with the highest degree of integration in the case, and blue parts in plans represent spatial positions with the highest degree of visual integration in the case.

Specific recommendations for policy changes and design that could support the development of cross-generational co-living spaces are as follows:

Urban Planning for Enhanced Community Interaction: Design urban spaces that encourage spontaneous interactions, with cluster and radial spatial forms being particularly beneficial for their versatility and flexibility, thus promoting cross-generational communication. Planning should prioritize spaces that are easily accessible to people of all ages, such as parks, community centers, and pedestrian-friendly streets. Encourage the incorporation of the cluster form in new urban developments and architectural designs, as these layouts are highly conducive to facilitating both direct and visual cross-generational communication. Policies should incentivize designs that incorporate communal spaces, fostering interaction among residents of different ages.

Support for Community Organizations and Incentive Programs: Provide funding and support to community organizations that play a crucial role in facilitating intergenerational interaction and support within co-living spaces. These organizations include community centers, local NGOs, and volunteer groups. Encourage the integration of a certain proportion of cross-generational co-living spaces in the development and design of residential communities, with incentives dependent on meeting relevant standards.

Establish Urban Design Guidelines: The findings from studies on cultural differences in elderly care and spatial configuration can serve as references for urban design guidelines. This includes designing spaces that are adaptable and have strong potential for interaction and focusing on the types and area proportions, like corridors, foyers, multi-functional halls, bars, entrance squares, and transitional areas like entrance grey spaces, cloisters, and courtyards that are conducive to direct cross-generational communication. Key locations for facilitating visual communication should include central areas of halls or squares, patio edges, intersections between foyers and halls or entrances and corridors, connections among multiple open spaces (including window openings and corridors), junctions between corridors and larger spaces or rooms, and long corridor junctions. Excluding auxiliary and service areas, maintaining close proportions between different spaces can reduce discreteness and enhance cross-generational communication.

Regular Space Assessments: In addition to quantitative calculations, regularly assess the needs and satisfaction of users of cross-generational co-living spaces. This feedback can guide the improvement of policies and practices to better serve the residents of the community. Support local organizations or researchers in conducting long-term observations and longitudinal studies that track changes over time.

Focus on Improving Inclusive and Sustainable Design: Design spaces that facilitate activities appealing to all age groups, promoting shared experiences and cross-generational learning opportunities. Ensure barrier-free access to buildings, public transportation, and community facilities by catering to the mobility needs of the elderly. Foster a socially sustainable environment that encourages community interaction, supports local businesses, and integrates with the neighborhood.

4.2. Current View and Challenges for Future Research

The research method of space syntax is based on the objective description of spatial form, but it is a software simulation after all. It cannot analyze the psychological changes or feelings of different users in the same spatial structure, nor can it distinguish the furnishings in the space, layout, landscape, etc. that are attractive to users. Space syntax can only consider space from a two-dimensional plane, and it cannot take into account the height of buildings or structures that interfere with line of sight. Space syntax is often used in the analysis of urban space. There are still certain deficiencies in spatial analysis and radius classification for residential scales, such as elderly communities. The above-mentioned shortcomings of space syntax will be analyzed with some new technologies, such as sensor equipment and monitoring instruments, to measure interaction efficiency in the field and conduct long-term longitudinal research among other approaches in future research to make a comprehensive analysis of the communication space of the elderly community.

In future research and designs, incorporating the specific needs of cross-generational interaction is an important part of the development of aging in community. In addition to the influence of emotional needs and cultural backgrounds, cutting-edge technological research on cross-generational co-living spaces is also important, such as the comfort of cross-generational spaces based on health [53] and virtual environments to promote intergenerational learning [54]. This study serves as the early foundation for the design guidelines for cross-generational co-living. In the follow-up plan, it is necessary to analyze the psychological changes or feelings of different users in the same spatial structure. In order to monitor the long-term effectiveness of cross-generational co-living spaces in reducing elderly loneliness and promoting mutual interaction, a 10-year longitudinal study, with annual assessments and data collection, will be proposed.

5. Conclusions

This study identifies five spatial forms of cross-generational co-living spaces. Among these, the cluster form emerges as the most effective in facilitating both direct and visual cross-generational communication. This is closely followed by the radial form, the bilateral linear form, and the centralized form. The one-lateral linear form, however, ranks lowest in terms of fostering such interactions. In terms of spatial types, certain areas are found to be particularly conducive to direct cross-generational communication. These include corridors, foyers, multi-functional halls, bars, entrance squares, transitional areas, such as entrance grey spaces, cloisters, and courtyards. Each of these spaces offers unique characteristics that promote interaction among different generations. Regarding the spatial locations that most effectively support visual communication, this study highlights several key areas: the central areas of halls or squares, the edges of patios, the points of connection between foyers and halls or entrances and corridors, the intersections of various open spaces (including window openings and corridors), the connections between corridors and large rooms or spaces, and the junctions of lengthy corridors. Furthermore, this study observes that, with the exception of auxiliary and service rooms, the effectiveness of cross-generational communication is enhanced when the sizes of different spaces within a building are closely aligned. This uniformity in spatial distribution is instrumental in facilitating movement and interaction within the space.

The findings not only provide case study verification and quantitative calculations for revealing spatial relationships in cross-generational co-living pattern; they also add a cross-cultural perspective, thereby enriching the literature on age-friendly design and active aging knowledge system, and they offer practical implications for architects, urban planners, and policymakers in order to help design communities that support healthy aging and complement cross-cultural research to develop urban and architecture design guidelines.

Author Contributions: Conceptualization, D.Z.; Methodology, N.S.; Software, D.Z.; Investigation, D.Z.; Data curation, D.Z.; Writing—original draft, D.Z.; Writing—review & editing, N.S. and Y.C.; Supervision, N.S. and Y.C. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Data Availability Statement: Data are contained within the article.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. Basic overview of buildings in the research cases.

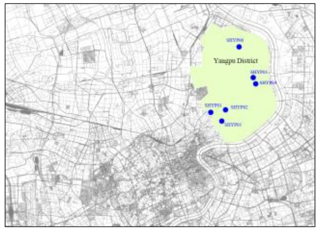
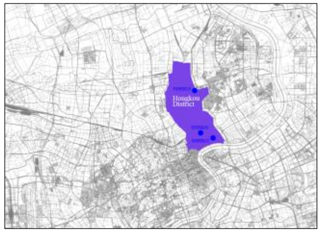
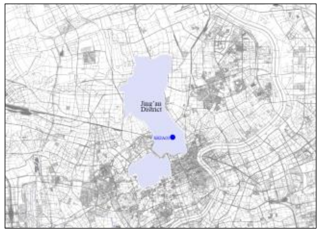
Research Area	Case Location	No.	Year of Use	Structure	Operator	Main Users	Floors	Service Range	Total
Yangpu district		SHYP01	2019	brick concrete	street neighborhood committee	elderly/children/ young adults	2	Anshan street	13
		SHYP02	2010	brick concrete	social organization	elderly	1	Yanji street	
		SHYP03	2012	frame structure	social organization	elderly/children/ young adults	2	Yanji street	
		SHYP04	2020	brick concrete	social organization	elderly	1	Jiangpu street	
		SHYP05	2009	frame structure	street neighborhood committee/ social organization	elderly/children/ young adults	2	Jiangwan international community	
Hongkou district		SHHK01	2020	frame structure	government	children/adults and youth	4	Jiaxing street	
		SHHK02	2021	brick concrete	street neighborhood committee	elderly	3	Xiangyan bridge street	
		SHHK03	2010	frame structure	Quyang neighborhood	elderly/children	4	Quyang community	
Jingan district		SHJA01	2017	frame structure	street neighborhood committee/social organization	elderly/young adults	3	Tianmu west street	

Table A1. *Cont.*

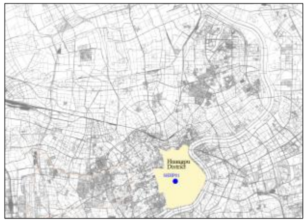
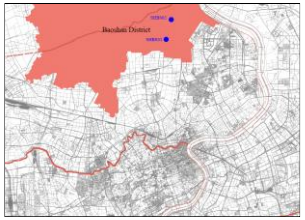
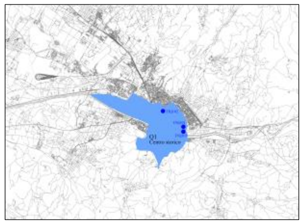
Research Area	Case Location	No.	Year of Use	Structure	Operator	Main Users	Floors	Service Range	Total
Huangpu district		SHHP01	2015	frame structure	street neighborhood committee/cultural center	elderly/children	4	Wuliqiao community	
Pudong New district		SHPD01	2020 interior renovation	frame structure	social organization	elderly	1	Weifang new village street	13
Baoshan district		SHBS01	2016	frame structure	street neighborhood committee	elderly/young adults	7	Gaojing town	
		SHBS02	2018	brick concrete	street neighborhood committee	elderly	1	Songnan street	
Q1 (Italian: Quartiere, neighborhood and community)		FIQ101	2013 (repair and reconstruction completed)	renovation of historic buildings	Commune di Firenze	elderly/children/young adults	multi-floor complex	Quartiere1 Centro storico	
		FIQ102	2001 (reconstruction completed)	renovation of historic buildings	Montedomini ASP	children/young adults/disabled people	3	Quartiere1 Centro storico	11
		FIQ103	1476 (original)	renovation of historic buildings	Montedomini ASP	elderly/young adults	3	Quartiere1 Centro storico	

Table A1. *Cont.*

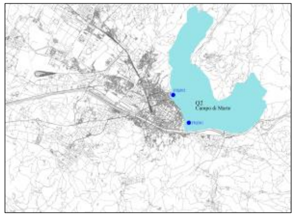
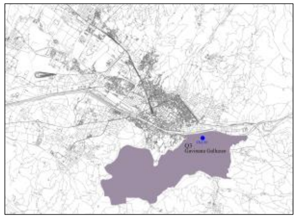
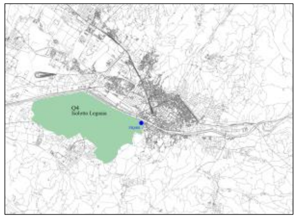
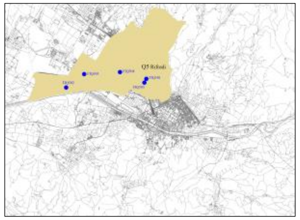
Research Area	Case Location	No.	Year of Use	Structure	Operator	Main Users	Floors	Service Range	Total
Q2		FIQ201	1975	brick concrete	Commune di Firenze	elderly/young adults	3	Quartiere2 Campo di Marte	11
		FIQ202	1937	brick concrete	Commune di Firenze	elderly	2	Quartiere2 Campo di Marte	
Q3		FIQ301	1944	frame structure	Arci	elderly/young adults	3	Quartiere3 Gavinana-Galluzzo	
Q4		FIQ401	1987	brick concrete	Commune di Firenze	elderly	1	Quartiere4 Isolotto-Legnaia	
Q5		FIQ501	1914	frame structure	SMS di Rifredi	elderly/young adults	2	Quartiere5 Rifredi	
		FIQ502	2014	frame structure	Azienda Usl Toscana Centro	elderly	2	Quartiere5 Rifredi	
		FIQ503	1959	frame structure	Arci	elderly/children/young adults	3	Quartiere5 Rifredi	
		FIQ505	1978	brick concrete	Commune di Firenze	elderly/young adults	1	Quartiere5 Rifredi	

Table A2. Illustration of the relationship between convex graphics and topology.

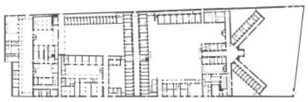
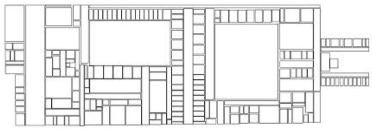
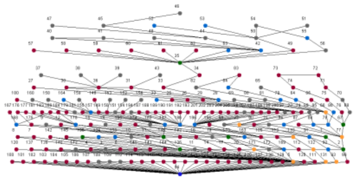
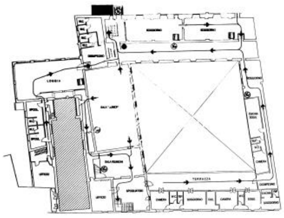
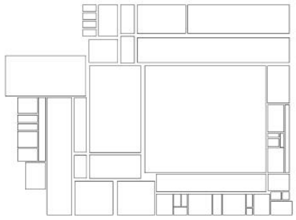
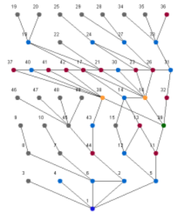
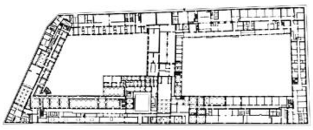
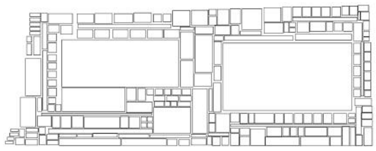
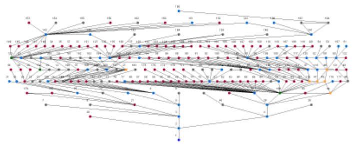
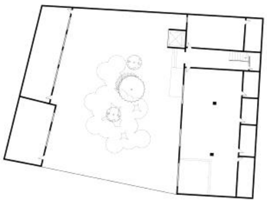
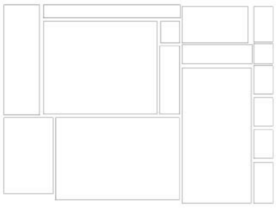
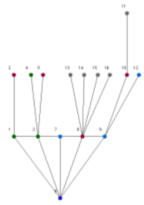
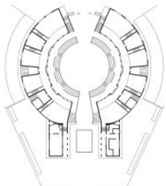
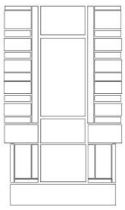
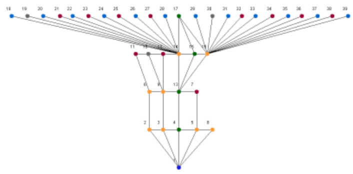
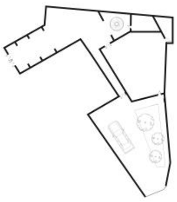
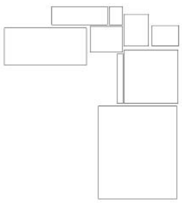
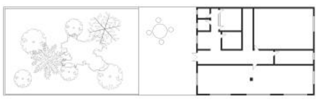
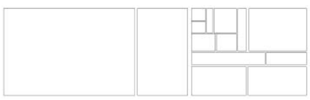
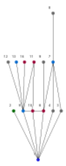
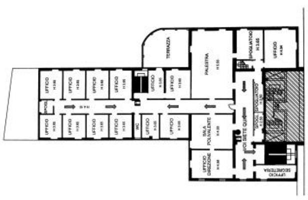
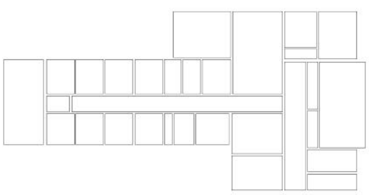
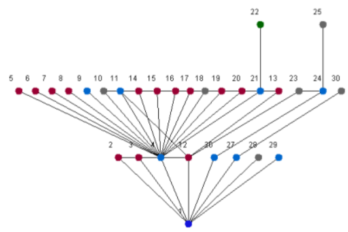
Case	Plan	Convexmap	Spatial Topology
FIQ101 Le Murate			
FIQ102 Cenacolo del Fuligno			
FIQ103 Montedomini			
FIQ201 Centro Eta'Libera "La luna-San Salvi"			
FIQ202 Centro Eta'Libera Parterre Aps			
FIQ301 Circolo A rci viale Giannotti			
FIQ401 Centro Anziani Eta'Libera Santa Rosa			
FIQ501 Statuto SMS Rifredi			

Table A2. *Cont.*

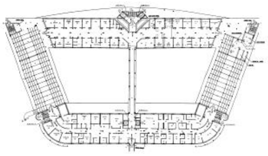
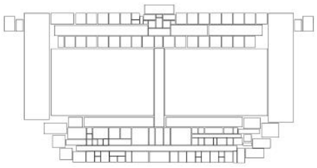
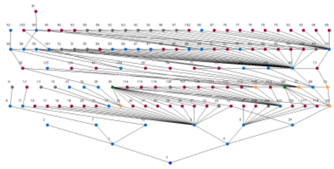
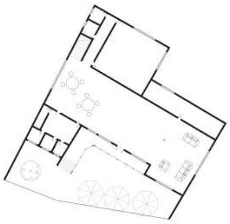
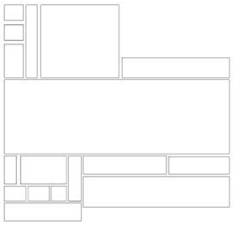
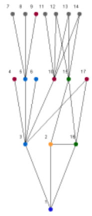
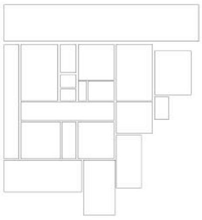
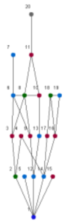
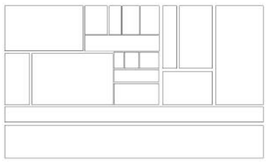
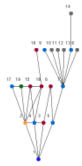
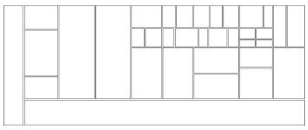
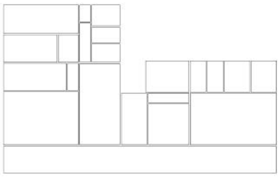
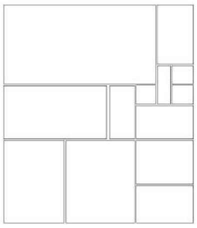
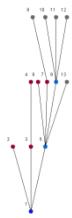
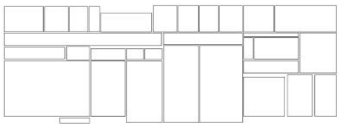
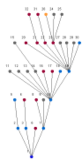
Case	Plan	Convexmap	Spatial Topology
FIQ502 Le Piagge			
FIQ503 Societa′ Mutuo Soccorso Ricreativo			
FIQ505 Centro Età Libera Rifredi Romito Vittoria			
SHYP01 Fushun Road Neighborhood Center			
SHYP02 Yanji Community No. 1 Neighborhood Center			
SHYP03 Yanji Community No. 3 Neighborhood Center			
SHYP04 Jiangpu Road Chenjiatou Neighborhood Center			
SHYP05 Jiangwan International Community Center			

Table A2. *Cont.*

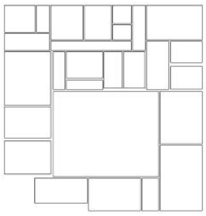
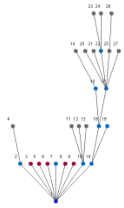
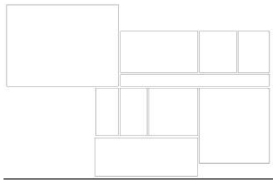
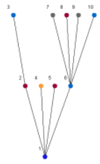
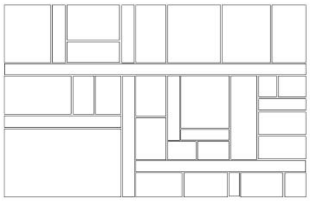
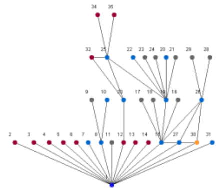
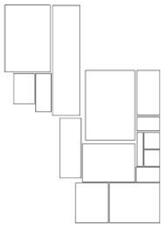
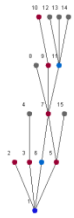
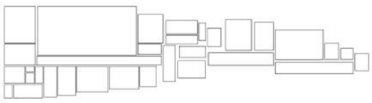
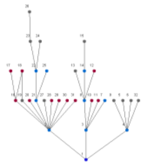
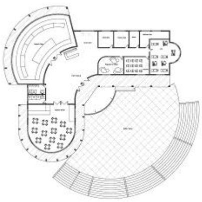
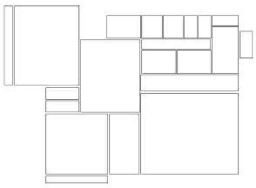
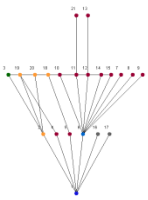
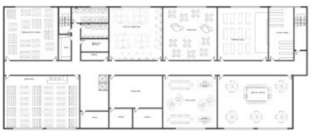
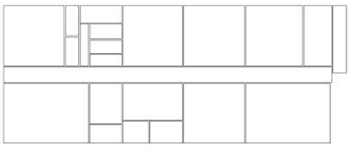
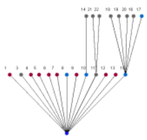
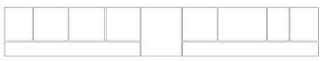
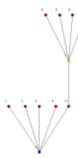
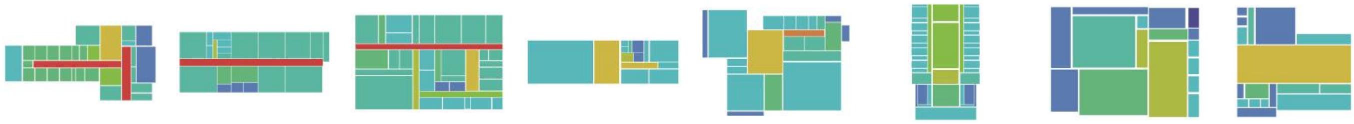
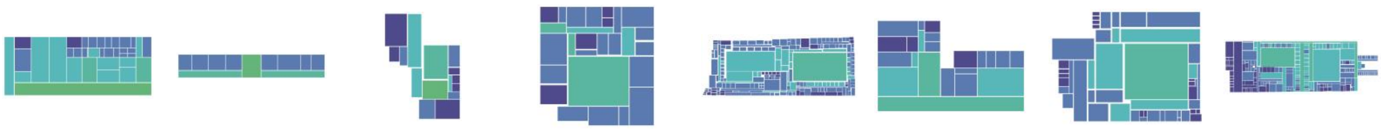
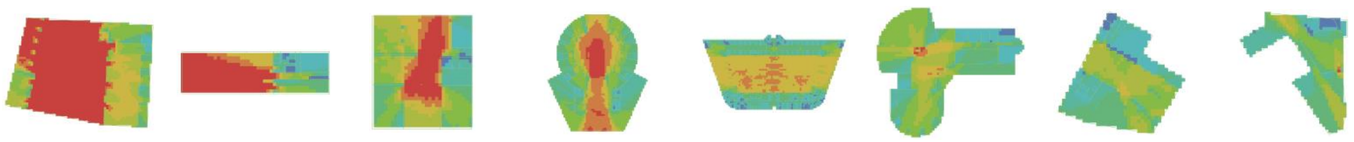
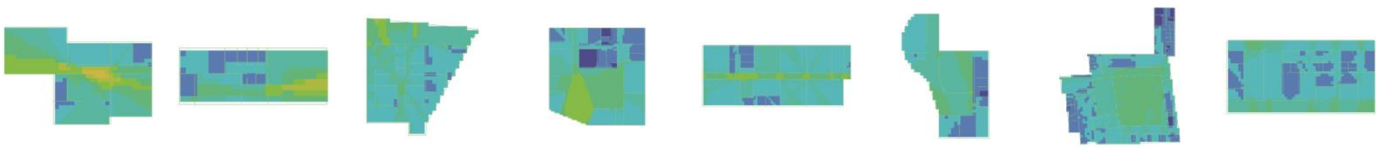
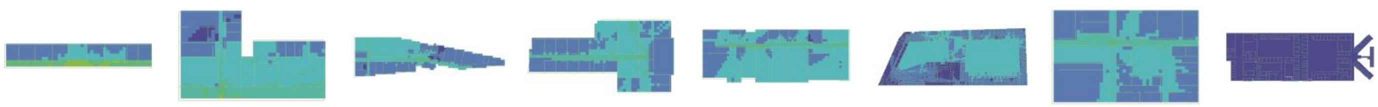
Case	Plan	Convexmap	Spatial Topology
SHHK01 Jiaxing Road Street Community Cultural Activity Center			
SHHK02 Jiaxing Road Street No. 5 Citizen Post Station			
SHHK03 Quyang Community Cultural Center			
SHJA01 Tianmu West Road Street Neighborhood Center			
SHHP01 Wuliqiao Community Cultural Activity Center			
SHPD01 Bamboo Garden Neighborhood Center			
SHBS01 Gaojing Town Community Cultural Activity Center			
SHBS02 Songnan Ten Villages Community Center			

Table A3. Visualization of unified scale integration (mean integration degree).

Numerical visualization of unified scale integration degree of convex graphics							
FIQ501 (1.781)	SHBS01 (1.67)	SHHK03 (1.509)	FIQ401 (1.41)	SHPD01 (1.409)	FIQ202 (1.359)	FIQ201 (1.263)	FIQ503 (1.263)
							
FIQ301 (1.243)	FIQ502 (1.224)	SHYP05 (1.16)	SHHK02 (1.106)	SHYP04 (1.009)	SHHP01 (1.008)	SHYP01 (0.99)	FIQ505 (0.965)
							
SHYP02 (0.96)	SHBS02 (0.955)	SHJA01 (0.954)	SHHK01 (0.938)	FIQ103 (0.907)	SHYP03 (0.905)	FIQ102 (0.871)	FIQ101 (0.869)
							
Statistics of sight diagram integration values							
FIQ201 (17.803)	FIQ401 (14.982)	SHYP04 (11.454)	FIQ202 (10.807)	FIQ502 (10.267)	SHPD01 (9.053)	FIQ503 (8.31)	FIQ301 (8.293)
							
SHHK02 (7.062)	SHYP01 (6.193)	FIQ505 (5.924)	SHHK01 (5.853)	SHBS01 (5.723)	SHJA01 (5.645)	FIQ102 (5.47)	SHYP02 (5.332)
							
SHBS02 (5.308)	SHYP03 (4.764)	SHHP01 (4.339)	FIQ501 (4.323)	SHYP05 (4.322)	FIQ103 (4.103)	SHHK03 (4.064)	FIQ101 (1.175)
							

References

1. Sciubba, J.D. Population aging as a global issue. In *Oxford Research Encyclopedia of International Studies*; Oxford University Press: Oxford, UK, 2020.
2. Boudoulas, K.D.; Triposkiadis, F.; Stefanadis, C.; Boudoulas, H. The endlessness evolution of medicine, continuous increase in life expectancy and constant role of the physician. *Hell. J. Cardiol.* **2017**, *58*, 322–330. [CrossRef]
3. Crimmins, E.M. Lifespan and Healthspan: Past, Present, and Promise. *Gerontologist* **2015**, *55*, 901–911. [CrossRef] [PubMed]
4. Bengtson, V.L. Beyond the nuclear family: The increasing importance of multigenerational bonds: The burges award lecture. *J. Marriage Fam.* **2001**, *63*, 1–16. [CrossRef]
5. Eckersley, R. Culture, health and well-being. In *The Social Origins of Health and Well-Being*; Hyde Park Press: Richmond, Australia, 2001; pp. 51–70.

6. Liang, Q.X.; Li, Y.Y.; Yang, S.H.; Zhou, H.X.; Wang, Z.W.; Huang, J.Q. The relationship between loneliness and living status of older people in rural area. *Chin. J. Gerontol.* **2006**, *26*, 1259–1260.
7. Lin, M.; Liu, Y.; Zhan, G. Empirical study on the urban elderly people of 'empty nest'and their loneliness. *Mod. Prev. Med.* **2009**, *36*, 77–80.
8. Son, H.; Cho, H.J.; Cho, S.; Ryu, J.; Kim, S. The Moderating Effect of Social Support between Loneliness and Depression: Differences between the Young-Old and the Old-Old. *Int. J. Environ. Res. Public Health* **2022**, *19*, 2322. [CrossRef]
9. Segrin, C. Age moderates the relationship between social support and psychosocial problems. *Hum. Commun. Res.* **2003**, *29*, 317–342. [CrossRef]
10. Hogan, D.P.; Spencer, L.J. Social support mediates loneliness and depression in elderly people. *J. Health Psychol.* **2016**, *21*, 750–758. [CrossRef]
11. Hogan, D.P.; Spencer, L.J. Kin structure and assistance in aging societies. *Annu. Rev. Gerontol. Geriatr.* **1993**, *13*, 169.
12. Reher, D.; Requena, M. Living Alone in Later Life: A Global Perspective. *Popul. Dev. Rev.* **2018**, *44*, 427–454. [CrossRef]
13. Jakobsen, P.; Larsen, H.G. An alternative for whom? The evolution and socio-economy of Danish cohousing. *Urban Res. Pract.* **2019**, *12*, 414–430. [CrossRef]
14. Pedersen, M. Senior Co-housing communities in Denmark. *J. Hous. Elder.* **2015**, *29*, 126–145. [CrossRef]
15. Van Gasse, D.; Wyninckx, B. Social Support Exchange in Shared Living Arrangements with Older Adults—Exploring the Benefits of Intergenerational Living for Older Adults. *J. Popul. Ageing* **2023**, 1–19. [CrossRef]
16. Scullica, F.A.; Borella, M.A.; Postell, J.C.; Veronese, G. 1. How to Live Together? Co-Living for Future Dwelling. In *Engaging Spaces*; Franco Angeli: Milano, Italy, 2022.
17. Dongqing, Z.; Setola, N.; Yi, C.; Naldi, E. Enhancing Wellbeing in Aging Communities through Environmental Design Elements: An Integrative Review of Literature in English, Chinese and Italian. *Int. J. Sustain. Dev. Res.* **2023**, *9*, 79–88. [CrossRef]
18. van Hoof, J.; Marston, H.R.; Kazak, J.K.; Buffel, T. Ten questions concerning age-friendly cities and communities and the built environment. *Build. Environ.* **2021**, *199*, 107922. [CrossRef]
19. Buffel, T.; Phillipson, C. *Ageing in Place in Urban Environments: Critical Perspectives*; Taylor & Francis: New York, NY, USA, 2024.
20. Quinio, V.; Burgess, G. Is co-living a housing solution for vulnerable older people? *Lit. Rev.* **2018**, 7–11. [CrossRef]
21. Aritakula, R.T. Co-Living: A Strategy for the Present. Ph.D. Thesis, University of Cincinnati, Cincinnati, OH, USA, 2023.
22. Bergan, T.L.; Gorman-Murray, A.; Power, E.R. Coliving housing: Home cultures of precarity for the new creative class. *Soc. Cult. Geogr.* **2021**, *22*, 1204–1222. [CrossRef]
23. Thang, L.L. Intergenerational relations: Asian perspectives. In *The SAGE Handbook of Social Gerontology*; SAGE: London, UK, 2010; pp. 202–214.
24. Dove, C. *Radical Housing: Designing Multi-Generational and Co-Living Housing for All*; Routledge: London, UK, 2020.
25. Ache, P.; Fedrowitz, M. The Development of Co-Housing Initiatives in Germany. *Built Environ.* **2012**, *38*, 395–412. [CrossRef]
26. Binette, J.; Farago, F. *Home and Community Preference Survey: A National Survey of Adults Age 18-Plus*; AARP Research: Washington, DC, USA, 2021.
27. Tahmaseb-McConatha, J.; Volkwein-Caplan, K.; DiGregorio, N. Culture, Aging and Well-being: The Importance of Place and Space. *Int. J. Sport Soc.* **2011**, *2*, 41–48. [CrossRef]
28. Ministry of Civil Affairs of the People's Republic of China, Social Service Development Statistics. Available online: http://www.mca.gov.cn/article/sj/tjgb/2017/201708021607.pdf (accessed on 20 January 2021).
29. Principi, A.; Di Rosa, M.; Domínguez-Rodríguez, A.; Varlamova, M.; Barbabella, F.; Lamura, G.; Socci, M. The Active Ageing Index and policy making in Italy. *Ageing Society* **2023**, *43*, 2554–2579. [CrossRef]
30. Wan, D.; Liu, H.; Guo, J.; Guo, L.; Qi, D.; Zhang, S.; Li, P.; Fukuda, H. Spatial Distribution and Accessibility Measurements for Elderly Day Care Centers in China's Urban Built-up Area: The Case of Tianjin Nankai District. *Buildings* **2022**, *12*, 1413. [CrossRef]
31. McCarthy, P. (Ed.) *Italy since 1945*; OUP Oxford: Oxford, UK, 2000.
32. Bettio, F.; Solinas, S. Which European model for elderly care? Equity and efficiency in home based care in three European countries. *Econ. Lav.* **2009**, *43*, 53–71.
33. Ma, Y.; Zou, G.; Siu, K.W.M.; Wong, Y.L. Social-Architectural Design of Community-Based Embedded Comprehensive Elderly Centers in China: Design Content and Process. Practice and progress in social design and sustainability. In *Practice and Progress in Social Design and Sustainability*; IGI Global: Hershey, PA, USA, 2019; pp. 94–116.
34. Gadakari, T.S.; Wang, J.; Hadjri, K.; Huang, J. Promoting Ageing-in-Place: Design of residential buildings for older people in China. *Environ.-Behav. Proc. J.* **2017**, *2*, 113–121. [CrossRef]
35. Gagliardi, C.; Di Rosa, M.; Melchiorre, M.G.; Spazzafumo, L.; Marcellini, F. Italy and the Aging Society: Overview of Demographic Trends and Formal/Informal Resources for the Care of Older People. In *Advances in Sociology Research*; Nova Science Publishers, Inc.: Hauppauge, NY, USA, 2012; Volume 13.
36. Fumagalli, N.; Fermani, E.; Senes, G.; Boffi, M.; Pola, L.; Inghilleri, P. Sustainable co-design with older people: The case of a public restorative garden in Milan (Italy). *Sustainability* **2020**, *12*, 3166. [CrossRef]
37. Bianchi, I. Co-living: Proposal for an innovative age-friendly cohabitation, in Aler's estate. 2020. Available online: https://hdl.handle.net/10589/170683 (accessed on 15 May 2023).

38. Capolongo, S.; Lemaire, N.; Oppio, A.; Buffoli, M.; Gall, A.R.L. Action planning for healthy cities: The role of multi-criteria analysis, developed in Italy and France, for assessing health performances in land-use plans and urban development projects. *Epidemiol. Prev.* **2016**, *40*, 257–264. [PubMed]
39. Capolongo, S.; Lemaire, N.; Oppio, A.; Buffoli, M.; Gall, A.R.L. Who will do more? The pattern of daily out-of-home activity participation in elderly co-residence households in urban China. *Cities* **2023**, *98*, 102586.
40. Benson, M. *Lifestyle Migration: Expectations, Aspirations and Experiences*; Routledge: London, UK, 2016.
41. Hillier, B.; Hanson, J. *The Social Logic of Space*; Cambridge University Press: Cambridge, UK, 1984.
42. Ostwald, M.J.; Lee, J.H. Computational Analytical Methods for Buildings and Cities: Space Syntax and Shape Grammar. *Buildings* **2023**, *13*, 1613. [CrossRef]
43. Brown, G.M. Design and value: Spatial form and the economic failure of a mall. *J. Real Estate Res.* **1999**, *17*, 189–225. [CrossRef]
44. Mohamed, A.A. Space Syntax Approach for Articulating Space and Social Life. In *Handbook of Research on Digital Research Methods and Architectural Tools in Urban Planning and Design*; IGI Global: Hershey, PA, USA, 2019; pp. 223–249.
45. Hillier, B.; Penn, A.; Hanson, J.; Grajewski, T.; Xu, J. Natural movement: Configuration and attraction in urban pedestrian movement. *Environ. Plan. B* **1993**, *20*, 29. [CrossRef]
46. Choi, Y.K. The morphology of exploration and encounter in museum layouts. *Environ. Plan. B Plan. Des.* **1999**, *26*, 241–250. [CrossRef]
47. Yamu, C.; van Nes, A.; Garau, C. Bill Hillier's Legacy: Space Syntax—A Synopsis of Basic Concepts, Measures, and Empirical Application. *Sustainability* **2021**, *13*, 3394. [CrossRef]
48. Zhang, X.; Cui, T. Evolution Process of Scientific Space: Spatial Analysis of Three Groups of Laboratories in History (16th–20th Century). *Buildings* **2022**, *12*, 1909. [CrossRef]
49. Zhao, X.; Moon, J. Analysis of Urban Spatial Accessibility of Museums within the Scope of Seoul. *Buildings* **2022**, *12*, 1749. [CrossRef]
50. Ching, F.D.K. *Architecture: Form Space & Order*, 4th ed.; Wiley: Hoboken, NJ, USA, 2014.
51. Zhang, Y.; Wu, Z.; Wu, Z.; Liu, Y.; Yang, Z. Using Space Syntax in Close Interaction Analysis between the Elderly: Towards a Healthier Urban Environment. *Buildings* **2023**, *13*, 1456. [CrossRef]
52. König, K.; Raue, M.; D'Ambrosio, L.A.; Coughlin, J.F. Coughlin. Physical and emotional support of the neighborhood for older adults: A comparison of the United States and Germany. *J. Environ. Psychol.* **2019**, *13*, 84–94. [CrossRef]
53. Wang, J.; Guo, J. Multiobjective Optimization of the Intergenerational Residential Space with the Goal of Daylighting and Thermal Comfort. *J. Green Build.* **2023**, *18*, 225–244. [CrossRef]
54. Cronan, G.; Fitzgerald, J.A.; Radford, K.; Di Perna, G. The Impact of a Virtual Environment for Intergenerational Learning. *Soc. Sci.* **2023**, *12*, 147. [CrossRef]