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The Spatial Signature of the Enclosure Paradigm in Chinese Housing

Evidence from Twelve Housing Areas

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ABSTRACT

'Enclosure, hierarchy and repetition' became a leading paradigm for housing design, especially in the West after WWII. This paradigm began to be questioned in the Anglophone literature, notably in early space syntax research. However, enclosed housing forms were a commonplace architectural solution for the past centuries in China. Consequently, little attention has been paid to date to the social constitution and spatial layout of Chinese enclosed housing areas, particularly from a configurational perspective.

Therefore, this paper aims to unravel the spatial signature of the enclosure paradigm in China by comparing six pairs of gated and non-gated housing schemes in the city of Wuhan. We compared the paired cases in relation to: (i) their setting within the city; (ii) tensions between peripheral and internal measures of centrality; (iii) multi-scale spatial cores; and (iv) overlap between potential to- and through-movement. We also aggregated land-use data at the junction segment level and compared functional density and diversity as an additional measure of local vs. neighbourhood vitality.

Our evidence suggests that compared with their non-gated counterparts, the gated housing estates are overall more segregated. Even if the gated estates occasionally demonstrate higher centrality on the periphery, their internal spaces are relatively isolated. Additionally, the gated compounds reveal a weaker overlap between movements, implying a lower likelihood of encounters. Furthermore, the gated estates tend to be mono-functional enclaves with lower functional density and diversity. We conclude that designing housing with the enclosure paradigm may contribute to an absence of internal vitality.

KEYWORDS

Gated housing, Enclosure paradigm, Housing form, Street centrality, Functional use

1 INTRODUCTION

Since the mid-twentieth century, there has been a widespread belief in housing design practice that breaking up large residential areas into small, inward-looking housing clusters would promote face-to-face interactions and reduce criminal behaviours by lowering population densities (Hillier, 2008). Having reviewed hundreds of housing schemes that follow this principle, Hillier points out that although these housing layouts vary geometrically, there is a paradigmatic universality beneath their morphology - the *'enclosure, repetition and hierarchy'* (Hillier, 1988: 63). This, at some stage, seemed to become an international style of housing design (Hillier, 1988), especially for the post-war social housing and therefore has been termed as the '*enclosure paradigm*' in the space syntax literature.

In the enclosure paradigm, housing is laid out within a clear boundary, with the bounded area become the smallest spatial element used to configure the housing layout. The areas are subsequently either repeated or geometrically transformed, to create an 'enclosure of enclosures' or 'cluster of clusters' at a higher level, namely a globally hierarchical system (Hillier, 1988: 63). The morphological features of modern housing estates that followed the enclosure paradigm were extensively discussed in Hanson's subsequent classic study of housing in Somers Town, London. She suggests that the morphologies of modernism are based on a neighbourhood unit, leading to a form that is generally *'small-scale, separate, inward-facing, unconstituted and hierarchical'* (Hanson, 2000: 112).

To be more specific, this housing paradigm leads to a typical street configuration that is broken up and tree-like, usually with great complexity and downscaling. Such layouts tend to be distinctive in plan, easily identified from axial maps of urban areas, and resulting in a strong configurational separation between the housing and its surroundings, which is termed as '*disurbanism*' by Bill Hillier (1996: 131). This disurbanism, is argued to result not only in a non-urban layout, but also has social consequences due to its impeding through-movement by people from elsewhere in the district (Hillier & Vaughan, 2007). Meanwhile, the street pattern of such housing estates follows a hierarchical system: vehicle and pedestrian movement are often separated; urban thoroughfares feed into more fragmented collector streets within the housing interior and then feeds into highly fragmented local streets used mainly to connect to dwelling clusters (Mehaffy et al., 2015). In other words, a minor alley does not directly link to a major thoroughfare in enclosed housing estates (Rofe, 1995).

Additionally, with the building form changing from low-rise to high-rise, the number of doors directly opening onto the streets decreases because numerous flats share one central entrance

(Friedrich et al., 2009). Meanwhile, those entrances are deliberately directed toward an inner courtyard or semi-public spaces (i.e., an inward-facing morphology) instead of the continuous urban streets. Consequently, only a few areas are constituted by the dwelling entrances that provide spaces identification and natural surveillance (Hillier, 1988). These constituted spaces are often relatively deep topologically from the outside – with many turnings away from the main street – (Hillier, 1996) and linked by unconstituted footpaths without doorways or even windows opening into them.

Furthermore, under the influences of the 'towers in the park' style invented by the early modernists (Le Corbusier, 1987); designers' priority of enclosed estates was to create more open space by minimising the building coverage on the ground. In such a housing scheme, open space is no longer constituted by smoothly changing yet continuous building facades. Instead, it is often defined by block boundaries and open space barriers, where buildings are free-standing or defining small green areas collectively to form a 'hollow heart' at the geometric centre of the estates (Hanson & Hillier, 1987). In such a scenario, physical permeability is substituted with a minimal visual connection to the streets, as physical boundaries restrict the accessibility in many bounded housing estates. In short, the enclosure paradigm tends to create a physically discrete and spatially identifiable housing area.

While previous space syntax studies in this research area have examined the enclosure paradigm of post-war housing in Europe, it is noteworthy that housing enclosure may take different forms in other cultural or geographical contexts because it tends to develop hand-in-hand with local values, beliefs, and practices (Tedong et al., 2014). A good example of this is China, where housing enclosures have been deeply rooted in design practice for hundreds of years (Liao et al., 2018). Unlike European countries that forecast the enclosure paradigm might help to relieve social malaise, and/or to shape community connections in the relatively anonymous urban setting, Chinese enclosed housing can be seen as a product of collective-oriented culture and tight governmental political controls (Zhao & Zou, 2017). More importantly, while the enclosure of Western post-war estates is manifested by their 'enclosed, hierarchical, and repetitive' layouts, with relatively minimal physical barriers, the enclosure of Chinese housing has till recent times been typified by physical boundaries such as walls and fences. This morphological difference thus triggers an interesting question: whether the enclosure paradigm of Western social housing is also manifested in Chinese enclosed estates, and: what are its social consequences?

Thus, this paper aims to investigate the spatial signature of the enclosed paradigm in China. Six pairs of gated and non-gated housing estates in Wuhan were compared regarding their overall centrality, movement interface and embeddedness into their immediate environs using space syntax methodology. Additionally, their density and diversity of functional uses were also compared. The result provides new findings on Chinese enclosed housing from an architectural perspective.

2 DATASETS AND METHODS

This comparative study is based on six pairs of gated and non-gated housing estates in Wuhan, China. The cases were selected for their comparability, with each pair sharing common features of proximity, size, housing price and construction year (see Figure 1 and Figure 2). In addition to comparability, the twelve areas were chosen for their variety in terms of layout and morphology, and to cover the breadth of typical housing forms in China. Notably, in our case studies, we also deliberately selected a comparative group of a gated (Yongqingcheng) and a semi-gated housing estate (The Riverview). As can be seen from Figure 2, The Riverview is composed of several gated clusters and shares some internal streets with the public. Examining this special case would reveal the configurational benefits of the semi-gated housing form (if any), compared to the full gated one. More detail about the selection and description of study cases were reported elsewhere (reference is masked for blind review).

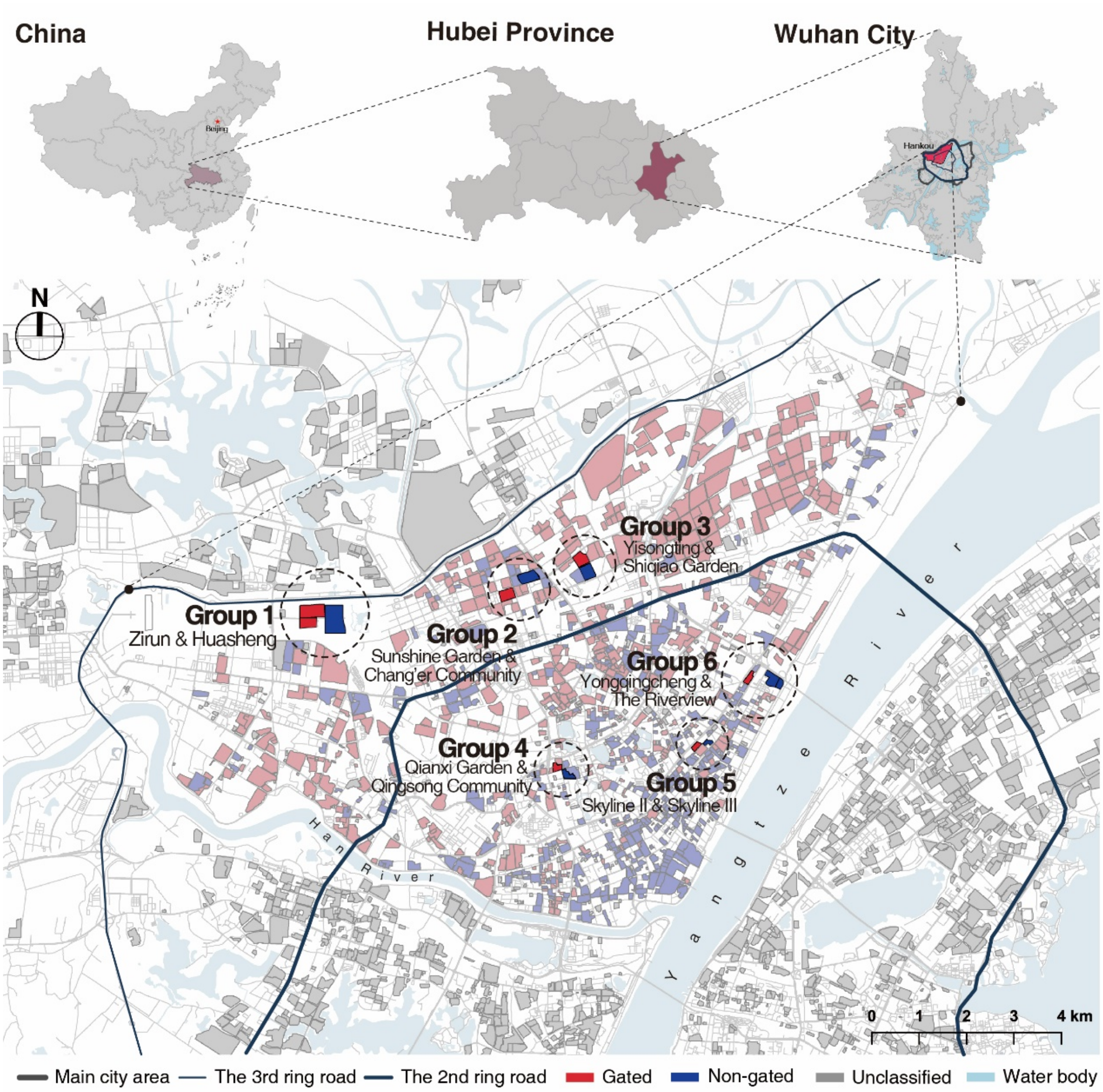


Figure 1. Location of twelve chosen housing estates in six comparative groups.

Figure 2. A general profile of the twelve chosen housing estates. Note that all figure-ground maps are presented in the same scale.

2.1 Comparing street network patterns

To quantitively compare the street network pattern between gated and non-gated estates, segment angular analysis was performed, using the model of the entire city, within which the estates are embedded. In other words, we provided a large enough buffer to avoid the 'edge effect' on the results (Gil, 2017). To further reduce the effects of different housing sizes and locations on the results, normalised angular Integration (NAIN) and Choice (NACH) were used for measuring street closeness and betweenness centralities, respectively (Hillier et al., 2012). While NAIN highlights the streets with the highest to-movement potentials within a given radius, NACH measures the potential of each segment being passed through within a set distance. NAIN and NACH were computed at six radii, ranging from local (400m and 800m), neighbourhood (1200m and 2000m), to wider city scales (4000m and 8000m). Having had the centrality of all streets quantified, the gated and non-gated housing estates were compared in detail from the following four aspects.

(1) Overall centrality within the city street network

The overall centrality compares the gated and non-gated housing estates in their average NAIN and NACH of all street segments, including both peripheral and internal streets. To determine the significance level of the comparison, bootstrapped independent samples *t*-tests were adopted with 20,000 iterations and 95% confidence intervals. This method is less sensitive to irregularities (e.g., outliers) and thus more robust compared to the standard *t*-test (LaFlair et al., 2015). The difference in means was considered statistically significant if the *p*-value was less than 0.05.

(2) Peripheral and internal differences on centrality

While the overall comparison of centrality provides a general picture of embeddedness or connectedness for the entire housing estate, it is worth examining the centrality of peripheral and internal streets separately, especially when the gated housing estates are involved. This is because the mean value is sensitive to the extremities of the range of values. For example, a housing estate may have an overall high means of centrality value simply because of its highly accessible periphery; however, this is less related to the housing layout or design, but more to the location of the housing estate within its wider urban setting. Therefore, we estimated the difference between peripheral and internal through the formula*: ((internal mean value) - (peripheral mean value)) / (peripheral mean value) *100*. This calculation shows to what extent (in percentages) does the internal centrality increase or decrease from the periphery.

(3) Multi-scalar spatial core

The spatial (or syntactic) core of a spatial system refers to a given percentage of the total spaces that take the highest syntactic values (Peponis et al., 1989). In this study, we defined the spatial core as the streets ranked in the top 10% syntactical value within a neighbourhood area (a 1200m buffer area around the housing estates) and examined these from two aspects: quantity and quality. The quantity refers to the extent that the studied housing estate contributes to the neighbourhood spatial core, measured by the percentage of the neighbourhood spatial core that appeared within the estate. A higher percentage suggests that the estate is more strongly embedded within its neighbourhood. The quality refers to the strength or attractiveness of the spatial core that found at the estate, measured by the ratio of the mean syntactic value of the spatial core within the housing estate to that of the total neighbourhood spatial core. If this ratio is greater than 1, the spatial core at the estate is stronger, thus more attractive to movement, than the spatial core of the overall neighbourhood, and vice versa.

(4) Movement interface

Movement interface suggests a correspondence degree between to- and through-movement potentials and can be measured by correlating NAIN and NACH at the same given radius (Vaughan, 2015). A higher correlation coefficient may indicate a greater opportunity for encounters between people who treat the place as a destination/origin and those who simply want to pass through the area, thus providing a higher probability of social interactions between them.

2.2 Comparing functional-use patterns

The data for functional analysis was a combination of Point-of-Interest (POIs) data and site survey data. POIs data have been considered as an alternative resource to conventional land use data based on parcel or plot, as they represent the location of functional uses at a fine-resolution (see Shen & Karimi, 2017; Yue et al., 2017). Although POIs can cover a great proportion of functional uses, a site survey was also conducted as a supplement to ensure the accuracy, correctness, and completeness of the data. Consequently, an integrated database for functional analysis was created for each studied housing area. A total of fourteen functional-use classes were identified from Baidu Map (the most popular navigation engine in China, similar to Google Map): accommodations, administrations, daily services, education, enterprises, finance, healthcare, public facilities, restaurants, recreations, residence, shops, transports, and vehicle services.

The gated and non-gated housing estates were first compared in their composition and distribution of functional uses. Additionally, the density and diversity of functional uses were also investigated. Note that, instead of measuring the density and diversity at the estate level, we calculated the density and diversity for individual street segments in the housing estates using the equations listed below in Table 1. Subsequently, the bootstrapped independent samples t-tests were applied again to statistically compare between gated and non-gated estates on their mean functional density and diversity of all street segments.

Table 1. Measurement of functional density and diversity

Category	Indicator	Equation	Explanation
Functional density	Functional density (D)	$D = \frac{\sum_{i=1}^{n} Numi}{Length} * 100$	Functional density is calculated by the division between junction segment length and the total number of adjacent POIs per 100 meters. A higher score refers to denser functional uses.
Functional diversity	Shannon entropy (H)	$H = -\sum_{i=1}^{n} p_i * \ln(p_i)$	P_i is the ratio of functional type *i* to all types adjacent to each segment. *n* is the total number of functional types.

3 RESULTS

3.1 Overall centrality of the cases within the street network

The results of normalised angular Integration (NAIN) and Choice (NACH) at six radii are shown in Figure 3. To remind the reader, the results were extracted from a large city model, in which all twelve housing estates are embedded. Box-and-whisker plots on the centrality data were generated for each pair of housing estates to visually compare mean, median, interquartile range, maximum and minimum values (Figure 4). Meanwhile, the significance levels of the bootstrapped independent samples *t*-tests are also reported in Figure 4. These were used to determine whether the two estates statistically differ in their overall centralities.

Starting with NAIN, the non-gated housing estates demonstrated higher means across all radii than their gated counterparts in three groups: Chang'er Community vs Sunshine Garden (Figure 4-b1), Qingsong Community vs Qianxi Garden (Figure 4-d1), and Skyline III vs Skyline II (Figure 4-e1). All these differences were verified as statistically significant by the *t*-tests. Reading from the maps, one can identify dark blue, segregated 'lumps' within Sunshine Garden (Figure 3-b), Qianxi Garden (Figure 3-d), and Skyline II (Figure 3-e), particularly with larger radii; conversely, their non-gated counterparts remain relatively integrated throughout the scales. More evidence will be provided on this point in the next section. What is slightly less consistent is the comparison between Huasheng and Zirun (Figure 3-a). Huasheng had statistically significantly higher means than its gated counterpart on four out of six radii (Figure 4-a1), namely, R400 (t = 2.832, p = .004), R800 (t = 2.839, p = .005), R4000 (t = 2.892, p = .004), R8000 (t = 8.824, p = .000). In other words, Zirun is overall more integrated at the neighbourhood scale.

Compared with the estates discussed above, the difference between Yisongting (gated) and Shiqiao Garden (non-gated) on NAIN is less distinct (Figure 3-c). According to the statistics, Yisongting showcased slightly higher means than Shiqiao Garden at all scales, albeit non-significantly, with only NAIN_R2000 (t = 3.144, p = .002) as an exception (Figure 4-c1). This is not surprising because although Shiqiao Garden does not have strictly controlled gates, its layout follows the design principle of modern estates – enclosure and hierarchy (see Figure 3-c). When it comes to the comparison between semi-gated (The Riverview) and gated (Yongqingcheng) housing areas, the semi-gated one demonstrated markedly lower average NAIN across all analysed radii, with the p-value of t-tests less than 0.05 (Figure 4-f1).

As regards NACH, there are two notable findings. One is that although the non-gated housing estates tend to have higher mean values, almost all comparative groups failed to provide statistically significant results at any scales (Figure 4), suggesting that gated and non-gated estates do not significantly differ from each other on overall through-movement potential. However, an exception is the comparison between Qingsong Community (non-gated) and Sunshine Garden (gated) (Figure 4-d2), where the former demonstrated significantly higher average NACH at R800 (t = 2.239, p = .024), R1200 (t = 1.969, p = .05), and R2000 (t = 2.028, p = .042). The other striking finding from the boxplots is that the lowest NACH is zero for all housing estates except Skyline III. These zeros reveal the existence of *cul-de-sacs* that can only be used as *origins/destinations* (Integration) but not be *passed through* (Choice). This may be why these housing estates do not significantly differ on their average NACH.

To conclude this section, the overall comparisons of multi-scalar centralities have suggested that the non-gated housing areas are more likely to show significantly greater to-movement potential than the gated compounds, especially at large scales. However, the difference between gated and non-gated becomes less distinct when it comes to the overall through-movement potential. Moreover, the result of the semi-gated case indicated that this housing form does not guarantee a more accessible layout.

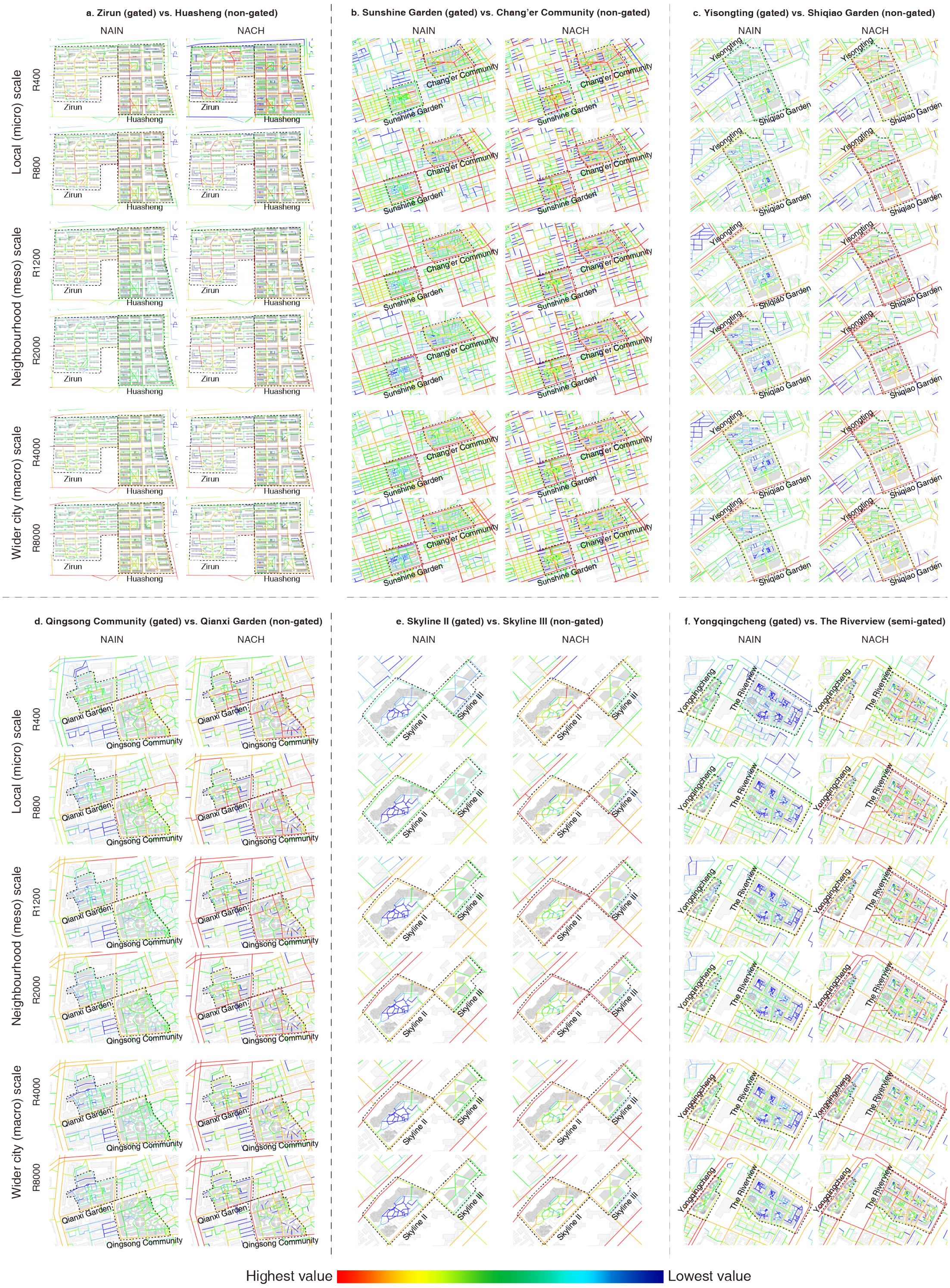


Figure 3. Normalised angular Integration (NAIN) and Choice (NACH) for twelve housing estates, with radii of 400, 800, 1200, 2000, 4000, and 8000 meters. Maps were coloured using the 'natural break' method.

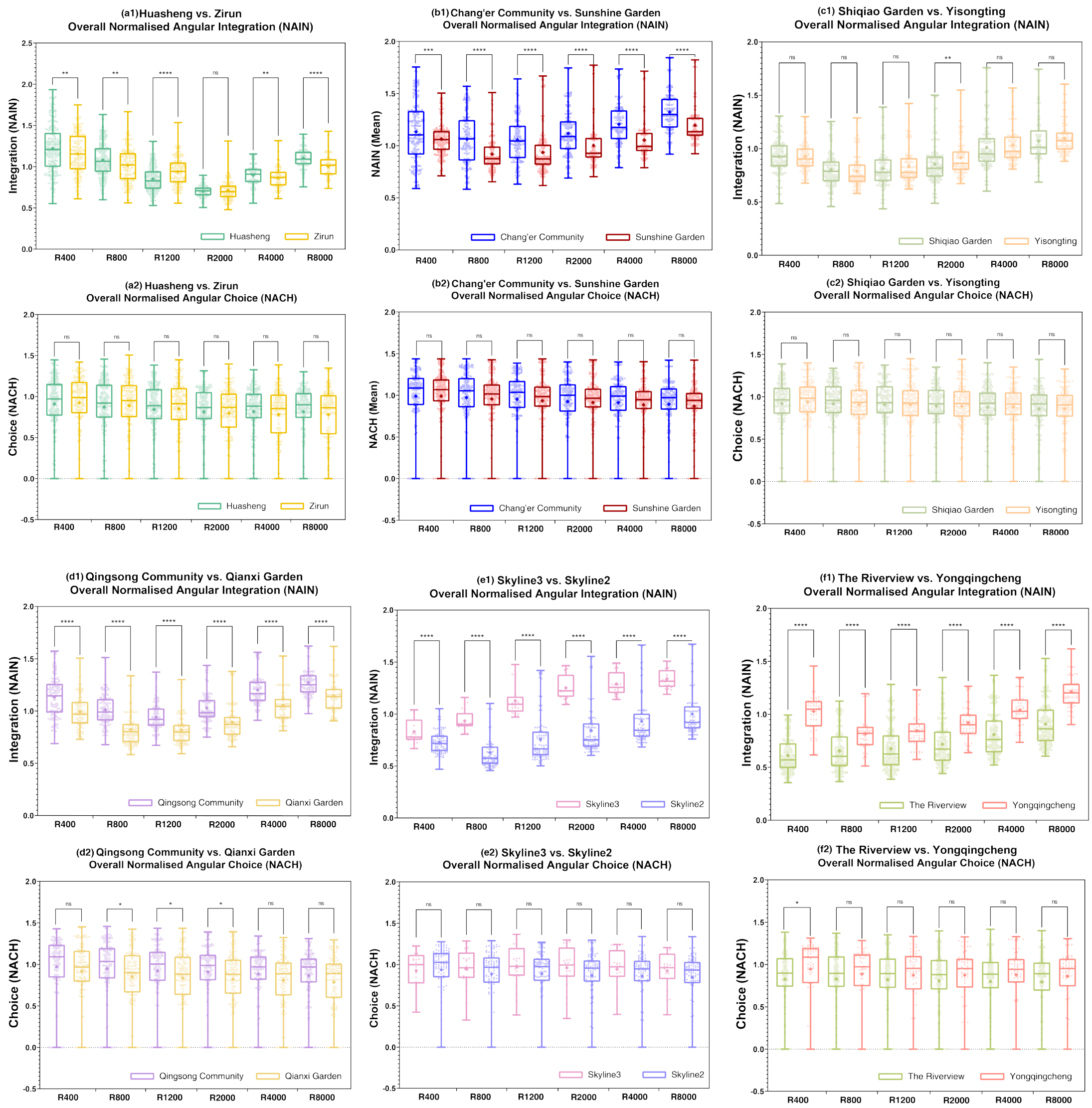


Figure 4. Box-and-whisker plot of NAIN and NACH for all twelve housing estates, showing the minimum, maximum, median, mean (the cross) value, and interquartile range of entire dataset. The results of t-test on means are also reported, where '****' indicates the significant level at 0.0001, '***' at 0.001, '**' at 0.01, and '*' at 0.05; whilst 'ns' means statistically non-significant results.

3.2 Peripheral and internal differences in measured centrality

Having compared the overall centrality, we pushed the analysis forward by examining the peripheral and internal centrality separately. The mean NAIN of peripheral and internal streets for six pairs of housing estates are reported in Figure 5, where the gated cases were shown in dots and non-gated in squares.

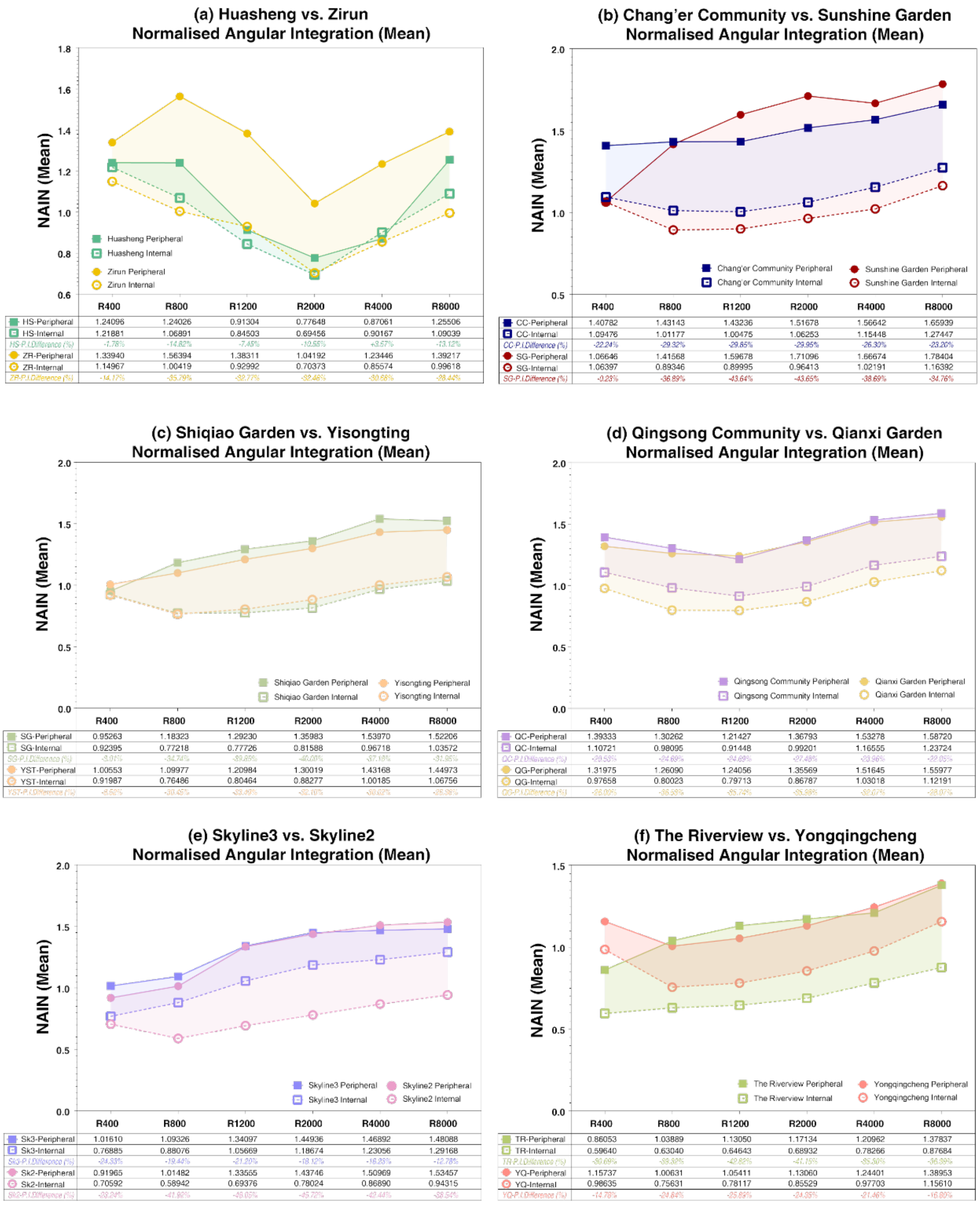
Notably, the spread of values for the peripheral-internal NAIN for the non-gated housing estates tends to be narrower than that for the gated ones (Figure 5), suggesting smaller differences between peripheral and internal NAIN. Importantly, these differences often come from the higher internal rather than lower external NAIN values of the non-gated estates. For example, the non-gated estates share similar peripheral but higher internal NAIN than the gated ones in three groups, shown in Figure 5-d, e, f. Moreover, even though the gated compound occasionally possesses high accessibility on its periphery, the internal space remained segregated and less accessible, such as in the case of Sunshine Garden in Figure 5-b.

Another noteworthy finding is the comparison of NAIN_R400. The analyses of the gated estates tend to show both lower peripheral and internal NAIN than the non-gated ones at this radius (Figure 5). This is particularly true for two groups (Figure 5-b, f), where the *peripheral* NAIN of the gated housing areas was even lower than the *internal* value of the non-gated ones. A probable reason for this extremely low peripheral centrality came from the gated housing form and superblock of these compounds *per se*: their lack of internal connections made the periphery hardly accessible at 400m scale.

This same situation also appeared when it came to NACH (Figure 6). Strikingly, the peripheral value of Zirun at R400m almost reached the bottom of the sample's range (Figure 6-a), and for the rest of the groups, the peripheral NACH_R400 of the gated estates is consistently lower than that of their non-gated counterparts. What is interesting is that once the radius hits 800m, the peripheral NACH of the gated estates usually surpasses that of non-gated ones and remains superior. However, the internal space of the gated estates fails to take advantage of its accessible periphery and sustains low levels of centrality. Consequently, compared to the non-gated cases, greater peripheral-internal differences on NACH were found in four gated schemes (Figure 6-a, b, c, d).

Regarding the comparison between the pairing of a gated (Yongqingcheng) and a semi-gated estate (The Riverview), here, the latter was found to closely resemble the gated case. For example, the average internal NAIN and NACH of The Riverview was lower than its gated counterpart at all scales, particularly for NAIN (Figure 5-f). Moreover, the average NAIN_R400 for the periphery of The Riverview were also notably lower than that of the gated estate. However, this value increased dramatically, exceeded the Yongqingcheng at R800 and remained high onwards. As has been seen from the previous paired cases, these characteristics are more typical for gated estates. Yongqingcheng, in contrast, demonstrated higher accessibility on the local scale (R400). Moreover, this estate's internal and peripheral streets co-varied across scales, indicating a correspondence between internal and external spaces.

Both peripheral and internal Shiqiao Garden (non-gated) and Yisongting (gated) shared a similar pattern of average NAIN (Figure 5-c) and NACH (Figure 6-c). While their internal means of NAIN and NACH were almost the same, the periphery of Shijian Garden was more accessible than that of Yisongting, particularly for through-movement. Therefore, despite the difference in gatedness, these two housing estates demonstrated similar centralities for their peripheral and internal areas. This reinforced the findings from Section 3.1 that these two housing estates did not statistically differ in their overall centralities.



	R400	R800	R1200	R2000	R4000	R8000
HS-Peripheral	1.24096	1.24026	0.91304	0.77648	0.87061	1.25506
HS-Internal	1.21881	1.06891	0.84503	0.69456	0.90167	1.09039
HS-P.I.Difference (%)	-1.78%	-14.82%	-7.45%	-10.55%	+3.57%	-13.12%
ZR-Peripheral	1.33940	1.56394	1.38311	1.04192	1.23446	1.39217
ZR-Internal	1.14967	1.00419	0.92992	0.70373	0.85574	0.99618
ZR-P.I.Difference (%)	-14.17%	-35.79%	-32.77%	-32.46%	-30.68%	-28.44%

	R400	R800	R1200	R2000	R4000	R8000
CC-Peripheral	1.40782	1.43143	1.43236	1.51678	1.56642	1.65939
CC-Internal	1.09476	1.01177	1.00475	1.06253	1.15448	1.27447
CC-P.I.Difference (%)	-22.24%	-29.32%	-29.85%	-29.95%	-26.30%	-23.20%
SG-Peripheral	1.06646	1.41568	1.59678	1.71096	1.66674	1.78404
SG-Internal	1.06397	0.89346	0.89995	0.96413	1.02191	1.16392
SG-P.I.Difference (%)	-0.23%	-36.89%	-43.64%	-43.65%	-38.69%	-34.76%

	R400	R800	R1200	R2000	R4000	R8000
SG-Peripheral	0.95263	1.18323	1.29230	1.35983	1.53970	1.52206
SG-Internal	0.92395	0.77218	0.77726	0.81588	0.96718	1.03572
SG-P.I.Difference (%)	-3.01%	-34.74%	-39.85%	-40.00%	-37.18%	-31.95%
YST-Peripheral	1.00553	1.09977	1.20984	1.30019	1.43168	1.44973
YST-Internal	0.91987	0.76486	0.80464	0.88277	1.00185	1.06756
YST-P.I.Difference (%)	-8.52%	-30.45%	-33.49%	-32.10%	-30.02%	-26.36%

	R400	R800	R1200	R2000	R4000	R8000
QC-Peripheral	1.39333	1.30262	1.21427	1.36793	1.53278	1.58720
QC-Internal	1.10721	0.98095	0.91448	0.99201	1.16555	1.23724
QC-P.I.Difference (%)	-20.53%	-24.69%	-24.69%	-27.48%	-23.96%	-22.05%
QG-Peripheral	1.31975	1.26090	1.24056	1.35569	1.51645	1.55977
QG-Internal	0.97658	0.80023	0.79713	0.86787	1.03018	1.12191
QG-P.I.Difference (%)	-26.00%	-36.53%	-35.74%	-35.98%	-32.07%	-28.07%

	R400	R800	R1200	R2000	R4000	R8000
Sk3-Peripheral	1.01610	1.09326	1.34097	1.44936	1.46892	1.48088
Sk3-Internal	0.76885	0.88076	1.05669	1.18674	1.23056	1.29168
Sk3-P.I.Difference (%)	-24.33%	-19.44%	-21.20%	-18.12%	-16.23%	-12.78%
Sk2-Peripheral	0.91965	1.01482	1.33555	1.43746	1.50969	1.53457
Sk2-Internal	0.70592	0.58942	0.69376	0.78024	0.86890	0.94315
Sk2-P.I.Difference (%)	-23.24%	-41.92%	-48.05%	-45.72%	-42.44%	-38.54%

	R400	R800	R1200	R2000	R4000	R8000
TR-Peripheral	0.86053	1.03889	1.13050	1.17134	1.20962	1.37837
TR-Internal	0.59640	0.63040	0.64643	0.68932	0.78266	0.87684
TR-P.I.Difference (%)	-30.69%	-39.32%	-42.82%	-41.15%	-35.30%	-36.39%
YQ-Peripheral	1.15737	1.00631	1.05411	1.13060	1.24401	1.38953
YQ-Internal	0.98635	0.75631	0.78117	0.85529	0.97703	1.15610
YQ-P.I.Difference (%)	-14.78%	-24.84%	-25.89%	-24.35%	-21.46%	-16.80%

Figure 5. Comparing the means of NAIN for peripheral and internal space across six radii. The 'P.I.Difference' refers to the degree of NAIN difference (in percentage) from peripheral to internal space. The non-gated cases are presented in square and gated are in circle.

	R400	R800	R1200	R2000	R4000	R8000
HS-Peripheral	1.05287	1.10494	1.06848	1.04031	1.03743	1.04440
HS-Internal	0.89591	0.85207	0.82436	0.79507	0.79805	0.79577
HS-P.I.Difference (%)	-14.91%	-22.89%	-22.85%	-23.57%	-23.07%	-23.81%
ZR-Peripheral	0.78908	1.33187	1.41010	1.35156	1.36862	1.33065
ZR-Internal	0.92683	0.87909	0.84049	0.78225	0.76600	0.76625
ZR-P.I.Difference (%)	+17.46%	-34.00%	-40.40%	-42.12%	-44.03%	-42.42%

	R400	R800	R1200	R2000	R4000	R8000
CC-Peripheral	1.21600	1.30177	1.31029	1.31140	1.28018	1.26033
CC-Internal	0.95789	0.92707	0.90340	0.87151	0.85931	0.84219
CC-P.I.Difference (%)	-21.23%	-28.78%	-31.05%	-33.54%	-32.87%	-33.18%
SG-Peripheral	1.13932	1.36651	1.41302	1.40506	1.37897	1.36443
SG-Internal	0.98120	0.93455	0.90882	0.88670	0.85896	0.84337
SG-P.I.Difference (%)	-13.88%	-31.61%	-35.68%	-36.89%	-37.71%	-38.19%

	R400	R800	R1200	R2000	R4000	R8000
SG-Peripheral	1.00630	1.25975	1.31423	1.30721	1.29056	1.26302
SG-Internal	0.91292	0.89137	0.87866	0.85878	0.84582	0.82696
SG-P.I.Difference (%)	-9.28%	-29.24%	-33.14%	-34.30%	-34.46%	-34.53%
YST-Peripheral	1.05110	1.22117	1.25313	1.23292	1.18528	1.15351
YST-Internal	0.92853	0.88212	0.87835	0.86221	0.85553	0.83688
YST-P.I.Difference (%)	-11.66%	-27.76%	-29.91%	-30.07%	-27.82%	-27.45%

	R400	R800	R1200	R2000	R4000	R8000
QC-Peripheral	1.24516	1.35841	1.36248	1.35374	1.30107	1.26900
QC-Internal	0.94115	0.90663	0.87502	0.86121	0.84061	0.82251
QC-P.I.Difference (%)	-24.42%	-33.26%	-35.78%	-36.38%	-35.39%	-35.18%
QG-Peripheral	1.25861	1.33702	1.35808	1.36043	1.29090	1.24193
QG-Internal	0.89742	0.82630	0.80824	0.79444	0.77911	0.76250
QG-P.I.Difference (%)	-28.70%	-38.20%	-40.48%	-41.60%	-39.65%	-38.60%

	R400	R800	R1200	R2000	R4000	R8000
Sk3-Peripheral	1.17618	1.22354	1.28504	1.27685	1.23536	1.19131
Sk3-Internal	0.84130	0.85340	0.86858	0.85410	0.84537	0.83235
Sk3-P.I.Difference (%)	-28.47%	-30.25%	-32.41%	-33.11%	-31.57%	-30.13%
Sk2-Peripheral	1.14757	1.23255	1.24633	1.25680	1.25167	1.22828
Sk2-Internal	0.91280	0.84777	0.85140	0.82582	0.81780	0.80411
Sk2-P.I.Difference (%)	-20.46%	-31.22%	-31.69%	-34.29%	-34.66%	-34.53%

	R400	R800	R1200	R2000	R4000	R8000
TR-Peripheral	1.00081	1.20537	1.22645	1.25319	1.23525	1.19841
TR-Internal	0.81462	0.80551	0.79490	0.77911	0.77326	0.76905
TR-P.I.Difference (%)	-18.60%	-33.17%	-35.19%	-37.83%	-37.40%	-35.83%
YQ-Peripheral	1.07838	1.09486	1.11279	1.14451	1.15215	1.09891
YQ-Internal	0.90546	0.82327	0.79928	0.78955	0.79054	0.78946
YQ-P.I.Difference (%)	-16.04%	-24.81%	-28.17%	-31.01%	-31.39%	-28.16%

Figure 6. Comparing the means of NACH for peripheral and internal space for six pairs of housing estates. The ‘P.I.Difference’ refers to the difference (in percentage) from peripheral to internal space. The non-gated cases are presented in square and gated are in circle. The symbol of peripheral space is solid and of internal is hollow.

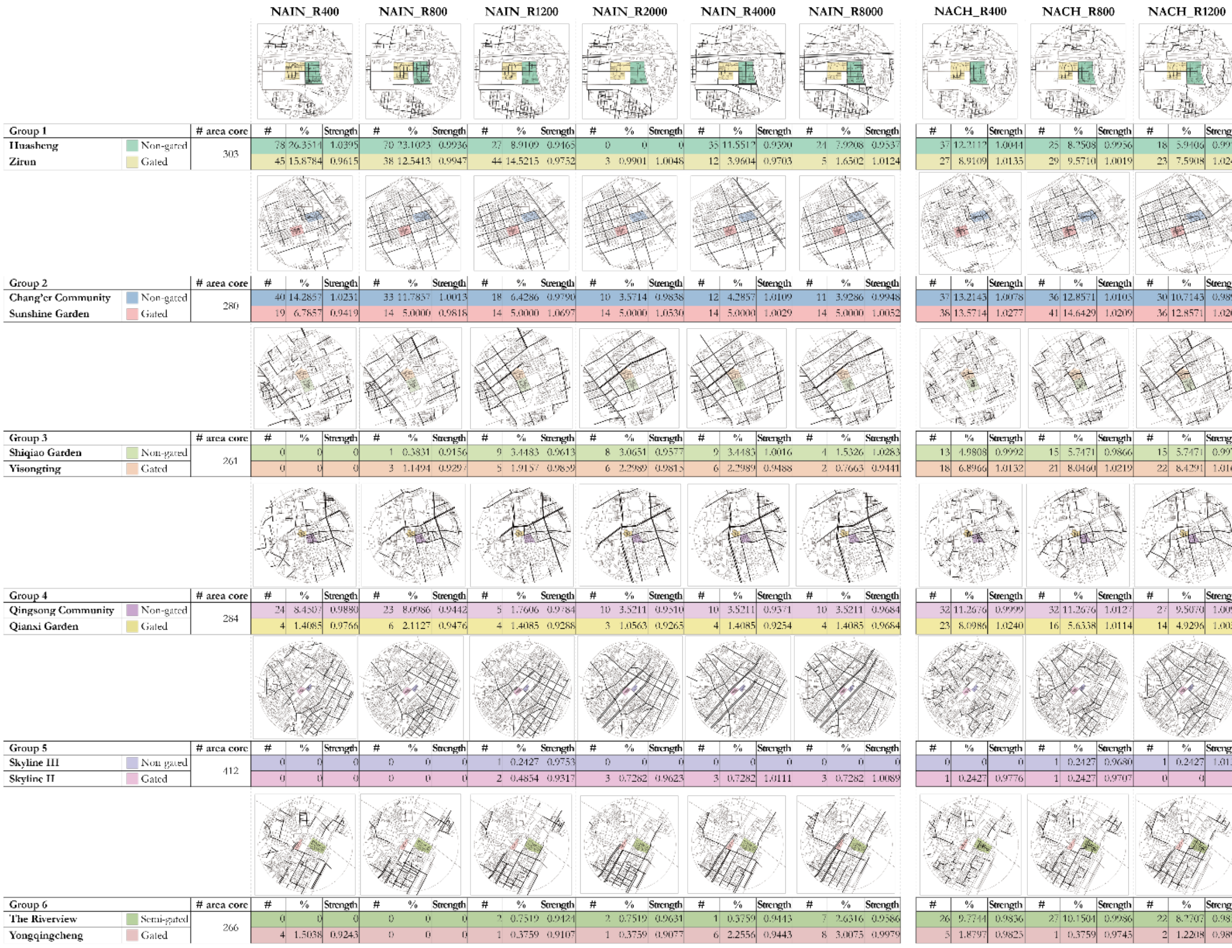
Overall, the analyses of peripheral and internal centrality have shown that while the gated cases are more likely to have greater movement potentials on the periphery, these compounds create an internal street layout that is relatively independent, being quite disconnected from its periphery. Consequently, the internal streets fail to take advantage or benefit from the connections onwards at their boundaries, and thus retain lower accessibility across all radii. More importantly, the lack of connections (i.e., entrances from the surroundings to the housing area) makes the periphery extremely difficult to access at the local scale (400m). Additionally, the analysis also revealed the semi-gated case having a pattern similar to the gated housing areas, suggesting that interventions such as sub-division into smaller clusters might potentially increase the movement on the periphery, yet the internal space within the clusters may remain inaccessible without careful design. Conversely, the non-gated estates generally demonstrate smaller peripheral-internal differences on centrality, particularly on the local scale, reflecting that the internal streets of the housing areas are more effectively connected with the outside world.

3.3 Multi-scalar spatial core

Figure 7 illustrates the neighbourhood spatial core comparison for the six groups of housing estates. The neighbourhood area was defined as a 1200m buffer area around the study cases. Starting with the integration cores, non-gated cases generally carried higher percentages of neighbourhood integration cores than the gated ones within the same comparative groups, except Group 5. This contrast became more distinct at local scales (R400 and R800), where the percentage of neighbourhood spatial cores that appeared at non-gated housing estates of Group 1, 2 and 4 was double that at their gated counterparts.

Regarding the strength of the integration core, six housing areas carried stronger average spatial cores than their overall neighbourhoods with a strength value above 1. Among the six, three are gated estates (Zirun, Sunshine Garden, and Skyline II) and three non-gated (Huasheng, Chang er Community, and Shiqdar Garden). Despite this equal number, the high strength appeared at the gated and non-gated estates with different radii. For the three non-gated estates, the spatial cores with the strength greater than one more frequently occurred at local scales (Huasheng: R400; Chang er Community: R400, R800, R4000; Shiqiao Garden: R4000, R8000). However, for gated cases, they were mostly at larger scales (Zirun: R2000, R8000; Sunshine Garden: R1200, R2000, R4000, R8000; Skyline II: R4000, R8000). This finding suggests that the non-gated estates tend to show greater attractiveness than their surroundings for pedestrian movement and gated ones for vehicle movement.

When it comes to the choice cores, a different situation occurred. In most cases, the gated compounds carried a higher proportion of the neighbourhood choice cores than non-gated areas, excepting Group 4 and 6. Moreover, the strength of choice cores is more frequently greater than 1 in gated cases (17/27) than non-gated (10/27). These findings suggested that gated compounds carried higher through-movement potentials than non-gated estates. Recalling the findings from peripheral and internal centrality analyses, we can conclude that this high attractiveness of through movement potential is predominantly derived from the periphery of gated compounds.



Group	Estate	Type	# area core	NAIN_R400 #	%	Strength	NAIN_R800 #	%	Strength	NAIN_R1200 #	%	Strength	NAIN_R2000 #	%	Strength	NAIN_R4000 #	%	Strength	NAIN_R8000 #	%	Strength
Group 1	Huasheng	Non-gated	303	78	26.3514	1.0395	70	23.1023	0.9936	27	8.9109	0.9465	0	0	0	35	11.5512	0.9390	24	7.9208	0.9537
	Zirun	Gated		45	15.8784	0.9615	38	12.5413	0.9947	44	14.5215	0.9752	3	0.9901	1.0048	12	3.9604	0.9703	5	1.6502	1.0124
Group 2	Chang'er Community	Non-gated	280	40	14.2857	1.0231	33	11.7857	1.0013	18	6.4286	0.9790	10	3.5714	0.9838	12	4.2857	1.0109	11	3.9286	0.9948
	Sunshine Garden	Gated		19	6.7857	0.9419	14	5.0000	0.9818	14	5.0000	1.0697	14	5.0000	1.0530	14	5.0000	1.0029	14	5.0000	1.0052
Group 3	Shiqiao Garden	Non-gated	261	0	0	0	1	0.3831	0.9156	9	3.4483	0.9613	8	3.0651	0.9577	9	3.4483	1.0016	4	1.5326	1.0283
	Yisongting	Gated		0	0	0	3	1.1494	0.9297	5	1.9157	0.9859	6	2.2989	0.9815	6	2.2989	0.9488	2	0.7663	0.9441
Group 4	Qingsong Community	Non-gated	284	24	8.4507	0.9880	23	8.0986	0.9442	5	1.7606	0.9784	10	3.5211	0.9510	10	3.5211	0.9371	10	3.5211	0.9684
	Qianxi Garden	Gated		4	1.4085	0.9766	6	2.1127	0.9476	4	1.4085	0.9288	3	1.0563	0.9265	4	1.4085	0.9254	4	1.4085	0.9684
Group 5	Skyline III	Non gated	412	0	0	0	0	0	0	1	0.2427	0.9753	0	0	0	0	0	0	0	0	0
	Skyline II	Gated		0	0	0	0	0	0	2	0.4854	0.9317	3	0.7282	0.9623	3	0.7282	1.0111	3	0.7282	1.0089
Group 6	The Riverview	Semi-gated	266	0	0	0	0	0	0	2	0.7519	0.9424	2	0.7519	0.9631	1	0.3759	0.9443	7	2.6316	0.9586
	Yongqingcheng	Gated		4	1.5038	0.9243	0	0	0	1	0.3759	0.9107	1	0.3759	0.9077	6	2.2556	0.9443	8	3.0075	0.9979

Group	Estate	NACH_R400 #	%	Strength	NACH_R800 #	%	Strength	NACH_R1200 #	%	Streng
Group 1	Huasheng	37	12.2112	1.0044	25	8.2508	0.9956	18	5.9406	0.99
	Zirun	27	8.9109	1.0135	29	9.5710	1.0019	23	7.5908	1.02
Group 2	Chang'er Community	37	13.2143	1.0078	36	12.8571	1.0103	30	10.7143	0.98
	Sunshine Garden	38	13.5714	1.0277	41	14.6429	1.0209	36	12.8571	1.02
Group 3	Shiqiao Garden	13	4.9808	0.9992	15	5.7471	0.9866	15	5.7471	0.99
	Yisongting	18	6.8966	1.0132	21	8.0460	1.0219	22	8.4291	1.01
Group 4	Qingsong Community	32	11.2676	0.9999	32	11.2676	1.0127	27	9.5070	1.00
	Qianxi Garden	23	8.0986	1.0240	16	5.6338	1.0114	14	4.9296	1.00
Group 5	Skyline III	0	0	0	1	0.2427	0.9680	1	0.2427	1.01
	Skyline II	1	0.2427	0.9776	1	0.2427	0.9707	0	0	
Group 6	The Riverview	26	9.7744	0.9836	27	10.1504	0.9986	22	8.2707	0.98
	Yongqingcheng	5	1.8797	0.9825	1	0.3759	0.9745	2	1.2208	0.98

Figure 7. Multi-scalar spatial core of neighbourhoods (1200m buffer area) where studied housing areas embedded. "# area core" refer
10% syntactic value in the neighbourhoods. "#" indicates the number of neighbourhood spatial cores that locate in studied housing e
of housing estates that take up the spatial core of the entire neighbourhood. "Strength" is the strength of spatial cores, measured by the r
in entire neighbourhoods and that in housing estates.

3.4 Movement interface

Movement interface measures the overlap of potential to- and through-movement, quantified as correlation coefficients of NAIN and NACH at the same radii. As shown in Table 2, the non-gated cases consistently demonstrate markedly higher coefficients than their gated counterpart across all radii. If we consider correlation above .70 as high correspondence, six housing areas were above this threshold (highlighted in bold in Table 2), of which five of are non-gated, suggesting that non-gated schemes generally provide a closer interface between to- and through-movement.

Additionally, in most cases, the model that contains both internal and peripheral streets (I+P) reveal a greater overlap than the one comprising internal streets only (IO). This result signifies a vital role of the peripheral streets in contributing to a configuration that can generate probabilistic encounters, as Hillier and colleagues would term it – namely, the opportunity for the housing area's inhabitants to encounter from elsewhere in the vicinity, and potentially interact with each other – particularly at the wider-scale radii (Hillier et al., 1987). When comparing the percentage of the difference between the two models, the first three pairs of cases witness smaller differences of non-gated areas, while the opposite is true for the last three groups. Despite the greater decreases of correlation between the two models for the non-gated cases in the last three groups, the coefficients are still much higher than gated compounds.

What is even more striking is that the correlation of five non-gated models only included internal streets is higher than that of gated with both internal and peripheral space. Furthermore, for gated housing areas, the proposition that movement interface is shaped by their layout falls apart if the streets outside of the perimeter are not included in the model. This finding points to the possibility that gated compounds generally rely more on the peripheral streets to create an overlap of movement flows, and once you enter the estates, the two categories of movement tend to separate, or diverge. Conversely, non-gated residential areas demonstrate a decent degree of movement interfaces, with or without peripheral streets.

The only exception to the above conclusion is the sixth group, where the gated case showcased much higher coefficients than the semi-gated area. However, this is not surprising because the semi-gated case was designed to share some internal streets for non-locals to pass through, thus creating a separation of to- and through-movement in nature.

Table 2. Movement interface of two twelve housing areas, measured by correlation coefficients between NAIN and NACH at the same radii. Coefficients above 0.7 were highlighted in bold.

	Housing Area	Type	Model	R400	R800	R1200	R2000	R4000	R8000
1	Huasheng	NG	I+P	**.702**	**.718**	.505	**.718**	.474	.626
			IO	**.710**	**.720**	.504	**.704**	.505	.603
			Diff	+1.140	+0.279	-0.198	-1.950	+6.540	-3.674
	Zirun	G	I+P	.661	.667	.647	.553	.575	.561
			IO	.540	.653	.621	.515	.528	.515
			Diff	-18.306	-2.099	-4.019	-6.872	-8.174	-8.200
2	Chang'er Community	NG	I+P	.691	.699	**.700**	.692	.678	.670
			IO	.671	.658	.650	.621	.587	.567
			Diff	-2.894	-5.866	-7.143	-10.260	-13.422	-15.373
	Sunshine Garden	G	I+P	.508	.511	.523	.507	.500	.488
			IO	.510	.460	.447	.410	.384	.358
			Diff	+0.394	-9.980	-14.532	-19.132	-23.200	-26.639
3	Shiqiao Garden	NG	I+P	**.707**	.697	**.707**	.686	.664	.648
			IO	**.708**	.678	.669	.640	.580	.550
			Diff	+0.141	-2.726	-5.375	-6.706	-12.651	-15.123
	Yisongting	G	I+P	.671	.690	.697	.673	.643	.626
			IO	.659	.658	.662	.628	.603	.582
			Diff	-1.788	-4.638	-5.022	-6.686	-6.221	-7.029
4	Qingsong Community	NG	I+P	**.739**	**.738**	**.743**	**.724**	.698	.680
			IO	**.734**	**.730**	**.737**	**.704**	.671	.649
			Diff	-0.677	-1.084	-0.808	-2.762	-3.868	-4.559
	Qianxi Garden	G	I+P	.639	.548	.588	.585	.547	.527
			IO	.621	.484	.524	.508	.467	.452
			Diff	-2.817	-11.679	-10.884	-13.162	-14.625	-14.231
5	Skyline III	NG	I+P	**.795**	**.812**	**.775**	**.838**	**.811**	**.754**
			IO	**.702**	**.767**	.569	**.703**	.572	.435
			Diff	-11.698	-5.542	-26.581	-16.110	-29.470	-42.308
	Skyline II	G	I+P	.535	.567	.564	.586	.594	.594
			IO	.518	.494	.485	.489	.490	.488
			Diff	-3.178	-12.875	-14.007	-16.553	-17.508	-17.845
6	The Riverview	SG	I+P	.580	.619	.606	.606	.590	.573
			IO	.586	.590	.572	.557	.537	.525
			Diff	+1.034	-4.685	-5.611	-8.086	-8.983	-8.377
	Yongqingcheng	G	I+P	**.782**	.700	**.751**	**.784**	**.801**	**.780**
			IO	**.788**	.677	**.721**	**.739**	**.732**	**.716**
			Diff	+0.767	-3.286	-3.995	-5.740	-8.614	-8.205

Note: "I+P" is the models that contains both internal and peripheral space, while "IO" contains internal space only. "NG" refers to non-gated cases, "G" to gated, and "SG" to semi-gated. "Diff" refers to the percentage of coefficient changes from "I+P" to "IO" model.

3.6 Functional-use distribution and composition

In addition to spatial centrality, another important spatial feature is the functional-use pattern. Figure 8 shows the distribution of different functional uses for each housing estate. Figure 9 integrates a bar chart and a stacked bar chart, illustrating the total number and share of different functional uses, respectively.

As expected, there is a greater percentage of non-residential uses in the non-gated estates (Huasheng: 68%, Chang er Community: 73%, Shiqiao Garden: 83%, Qingsong Community: 80%, Skyline III: 94%) than the corresponding gated ones (Zirun: 58%, Sunshine Garden: 62%, Yisongting: 60%, Qianxi Garden: 51%, Skyline II: 86%). When it comes to Yongqingcheng and The Riverview, the gated estate (former) displayed a distinctively higher proportion of non-residential uses than the semi-gated counterpart (latter), accounting for 84% and 42%, respectively. This implies that non-gated estates generally provide more non-residential uses than gated ones, and the semi-gated housing form does not necessarily guarantee more diverse uses.

Notably, in most of the cases, the greatest proportion of non-residential uses is “Shops” or “Restaurants” (Figure 9). However, one exception is Huasheng, where the greatest share belongs to “Vehicle services”, accounting for 55% of total functional uses on the ground floor. This makes the case interesting because even though these vehicle maintenance shops are non-residential functions, they are mostly used by drivers than pedestrians. In other words, these vehicle-related shops might not necessarily encourage human activities on the streets.

In addition to the percentage, how many functions the estates afford is equally important. According to the bar chart (Figure 9), the non-gated areas (names in italic) show more functional uses than gated ones in five groups, excepting the pair comprising Yisongting and Shiqiao. As for where these functional-uses are located, it is noticeable that the gated estates almost “pushed” the entire non-domestic functions out, demonstrating mono-functional enclaves; in contrast to the non-gated estates, where one can find plenty of non-residential functions inside the area, particularly for Huasheng, Chang’er Community, Qingsong Community and Skyline III (see Figure 8).

The evidence discussed so far has preliminarily suggested that non-gated housing forms tend to offer a higher number of, and more diverse function uses, particularly for the internal spaces. The following sections will further verify this conjecture through more precise segment-level analysis.

Figure 8. Distribution of functional uses in twelve housing areas.

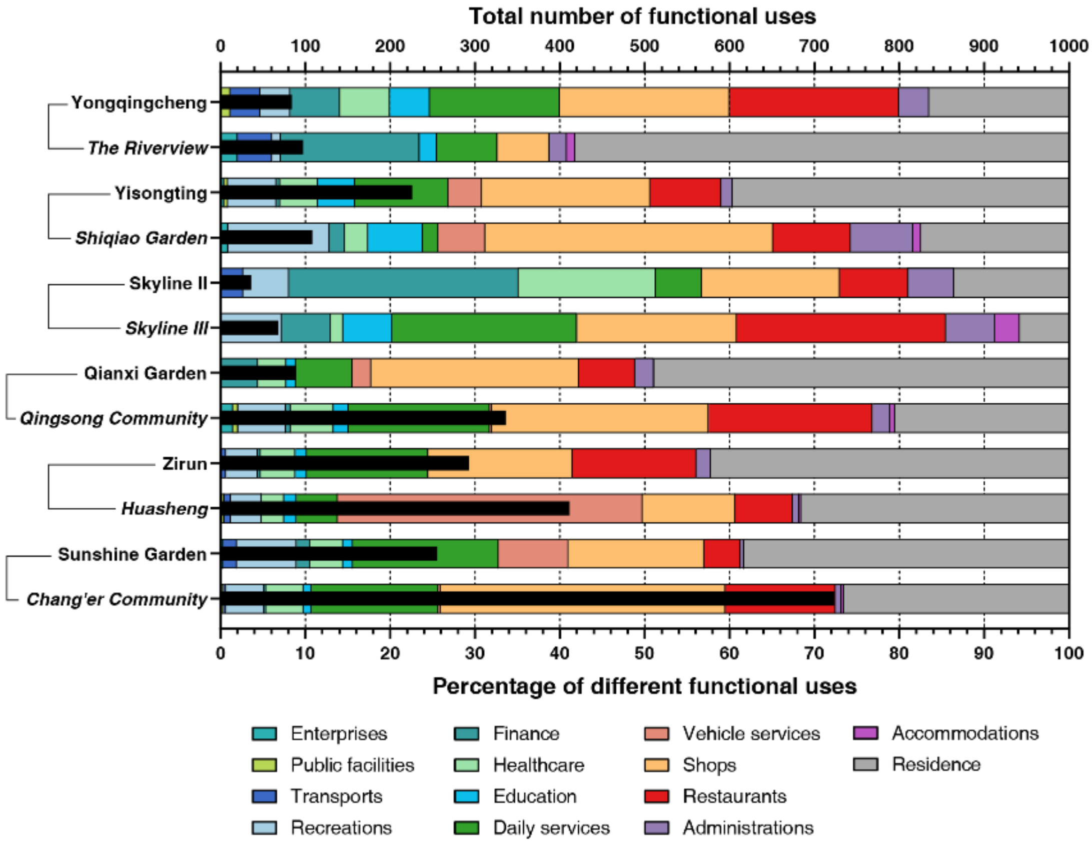


Figure 9. Composition and number of functional uses for twelve housing areas. Names in italics are non-gated cases.

3.7 Functional-use density

The functional-use density and diversity results for street segments in twelve housing estates are shown in Figure 10, where the mean (the thick line) and standard deviation (the whiskers) for each case are also reported. Two housing areas in comparison were linked by a black line and outcomes of bootstrapped independent samples t-tests on their means were reported above the line.

Starting with the functional-use density, as shown in Figure 10-a, the non-gated housing estates displayed higher means than their gated rivals in four (out of six) groups: Huasheng (3.674) vs Zirun (2.416); Chang'er Community (11.348) vs Sunshine Garden (2.294); Qingsong Community (10.501) vs Qianxi Garden (2.404); Skyline III (9.797) vs Skyline II (1.827). All these comparisons were statistically significant. The means of function mixing degree is the highest in Chang'er Community, followed by Qingsong Community, indicating that traditional communities allocate more functions on the ground floor (see Figure 8). Skyline III came to the third, which is a modern, non-gated complex where the ground floor is for commercial purposes.

However, there is a group where the gated estate (Yisongting: 4.625) showed a higher average density than its non-gated rivals (Shiqiao Garden: 1.974), t (310) = -3.414, p = .001. This reflects the fact that despite being non-gated, Shiqiao Garden is a typical modern high-rising building, where numerous flats are controlled by a handful of entrances on the ground floor. Yisongting, in contrast, is equipped with yards where many residents on the ground floor have installed entrances directly leading to their flat (Figure 8).

When it comes to The Riverview and Yongqingcheng, a different situation appeared. As Figure 10-a shows, the former (1.896) is significantly lower than the latter (3.371) regarding their functional density on average, t (314) = -3.414, p = .020. This is not surprising because although The Riverview is semi-gated, the façade of each gated cluster facing outwards on the ground floor remains fenced, which creates overwhelmingly unconstituted spaces (Figure 8). Conversely, the outwards-facing ground floor of Yongqingcheng provides plentiful functions, resulting in the high functional density of its periphery (Figure 8).

3.8 Functional-use diversity

Considering Figure 10-b, the non-gated housing estates demonstrated higher means of diversity index than their gated counterparts in four groups: Huasheng (0.116) vs Zirun (0.104); Chang'er Community (0.303) vs Sunshine Garden (0.063); Qingsong Community (0.320) vs Qianxi Garden (0.051); Skyline III (0.843) vs Skyline II (0.127). Among them, only the comparison between Huasheng and Zirun failed to be statistically significant, t (409) = .374, p = .703.

The remaining two groups displayed opposite results than the above: the gated scenarios were more diverse than the non-gated ones. The average Shannon diversity index was slightly higher in Yisongting (0.131) than Shiqiao Garden (0.103). However, this comparison was also not significant, t (310) = -.741, p = .463. Moreover, two cases showcased a similar pattern: the highest mixed-use streets are the periphery, while the internal is mostly monofunctional or unconstituted (Figure 8).

A more distinct comparison can be seen between Yongqingcheng (0.233) and The Riverview (0.023), where the entropy of the gated estate was significantly higher than that of the semi-gated one, t (51.802) = -3.249, p = .011. Although the semi-gated estate divides the plot into small clusters, the façade of each block facing outwards on the ground floor remains fenced, resulting in overwhelmingly mono-functional and unconstituted junction segments (see Figure 8). Conversely, despite being gated, the outwards-facing ground floor of Yongqingcheng is devoted to non-residential uses.

What stands out in Figure 10-b is Skyline III, which has evidently the highest average diversity value amongst all cases. Moreover, unlike other study cases, its lowest standard deviation value did not go below zero. This means that the other eleven residential areas are dominated by monofunctional and unconstituted streets (i.e., the diversity value equals zero), but Skyline III is occupied by a large proportion of mixed-use spaces (see Figure 10-b).

All in all, the findings of functional diversity analysis suggested that non-gated housing areas tend to be more diverse than gated ones, and that semi-gated estates do not necessarily mean high functional diversity.

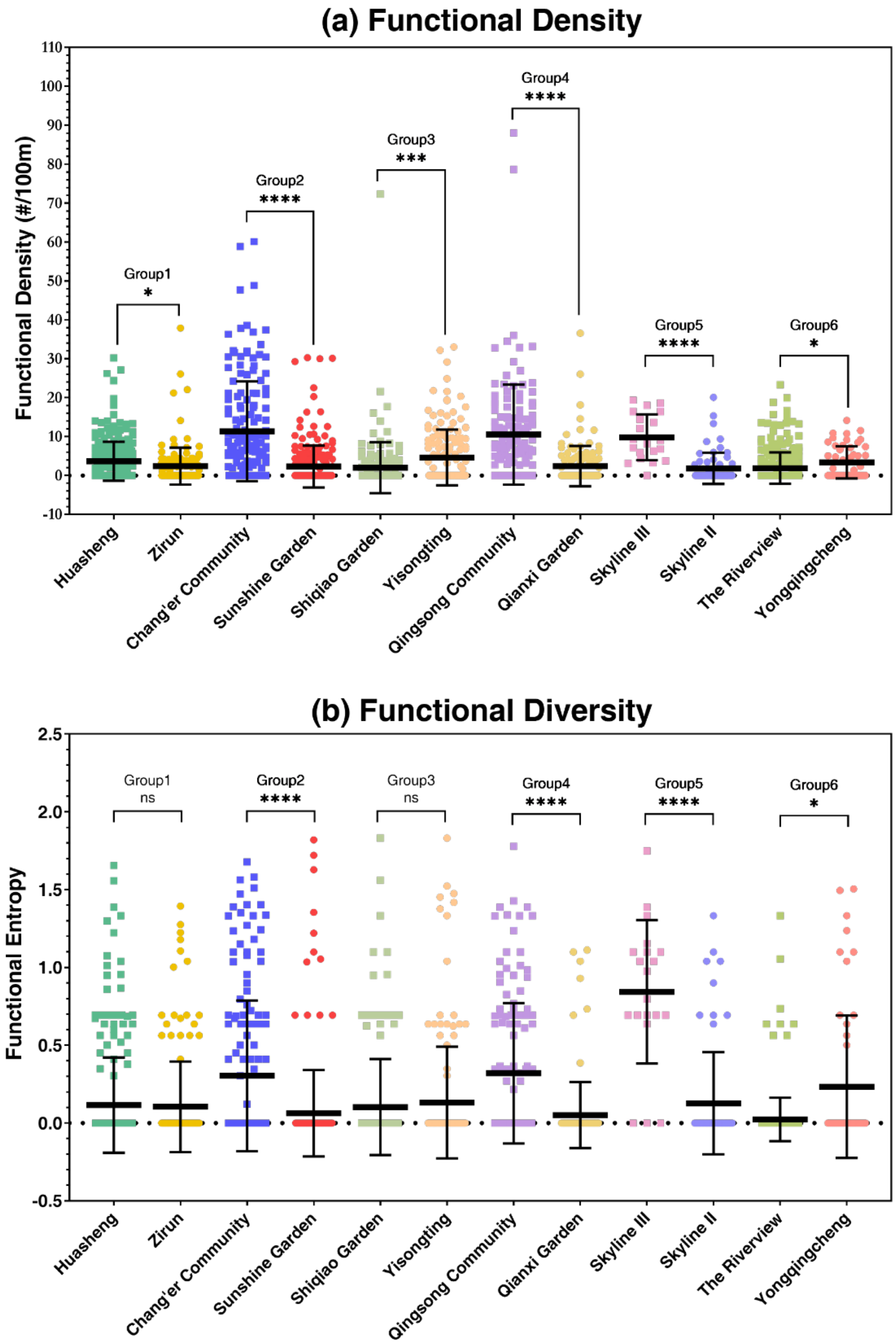


Figure 10. Scatter dot plot shows (a) the functional density and (b) diversity of junction segments, grouped by housing area. The data for non-gated areas is square and for gated is circular. For each group, bars (the thick lines) and error bars (the whiskers) represent mean and standard deviation, respectively. Stars indicate the significant level of the bootstrapped independent sample t-tests on means: '****' for significance at 0.001 level, '***' for 0.005, '**' for 0.01, '*' for 0.05, and 'ns' for non-significance.

4 CONCLUSION AND DISCUSSIONS

This study has examined the enclosure paradigm in China by comparing the configurational and morphological differences between Chinese gated and non-gated housing estates. In particular, it has been evidenced that gated housing schemes showcase significantly lower overall to-movement potential than non-gated ones, especially at large scales. However, few statistically significant differences were determined on their overall through-movement potential.

Our findings have further suggested that although the gated compounds are more likely to have greater movement potentials on the periphery, they create segregated internal systems that are independent and less susceptible to their peripheries. More importantly, the lack of connections (i.e., entrances) and superblock morphology make their peripheries morbidly inaccessible at the local scale (400m). Conversely, non-gated estates have reached a better balance between peripheral and internal centralities, resulting in stable and reasonable accessibility across all scales. In addition, learning from the semi-gated housing estate, we can conclude that simply dividing the plot into smaller gated clusters does not guarantee a more accessible layout.

Furthermore, our findings of movement interface have indicated that the gated housing estates are witnessed a greater interrupted interface between potential to- and through-movement than their non-gated counterparts, manifested by much lower NAIN-NACH correlations. More strikingly, the gated estate's proposition of movement interface falls apart without the perimeter, suggesting that once people enter the estate, the flow of pedestrians disperses.

This paper has also provided evidence on the functional-use patterns. Perhaps unsurprisingly, the non-gated estates provide more non-residential uses than gated ones. More importantly, our functional density and diversity analyses at the segment level have further confirmed that the gated housing generally display significantly lower functional density and diversity. Due to the human intervention (i.e., installing fences and gates), all non-residential functions are pushed outside the compounds to leave the internal purely monofunctional.

Based on all the evidence above, we further conclude that the layout of the Chinese gated schemes examined in this paper fails to provide a 'potential field of probabilistic co-presence and encounter' (Hillier et al., 1987) for social interactions and economic exchanges to flourish. This conclusion echoes early space syntax studies on English post-war housing, where the enclosure paradigm – this 'hard solution' – failed to solve urban problems but cultivate the seed of destruction (Hanson, 2000; Hillier & Hanson, 1984). However, one of the challenges China is facing to un-gate the housing is people's attachments to the 'enclosure paradigm' that is deeply rooted in their culture; therefore, a tailored strategy is needed to remove the physical boundaries whilst offering certain privacy through the configuration of the layout.

REFERENCES

Le Corbusier. (1987). *The city of to-morrow and its planning*. Courier Corporation.

Friedrich, E., Hillier, B., & Chiaradia, A. (2009). Anti-social behaviour and urban configuration using space syntax to understand spatial patterns of socio-environmental disorder. Seventh International Space Syntax Symposium, Stockholm: Royal Institute of Technology.

Gil, J. (2017). Street network analysis “edge effects”: Examining the sensitivity of centrality measures to boundary conditions. *Environment and Planning B: Urban Analytics and City Science*, *44*(5), 819-836.

Hanson, J. (2000). Urban transformations: a history of design ideas. *URBAN DESIGN International*, *5*(2), 97-122.

Hanson, J., & Hillier, B. (1987). The architecture of community: Some new proposals on the social consequences of architectural and planning decisions. *Architecture et Comportement/Architecture and Behaviour*, *3*(3), 251-273.

Hillier, B. (1988). Against enclosure. *Rehumanizing housing*, *2*, 25.21-25.11.

Hillier, B. (1996). *Space is the machine: a configurational theory of architecture*. Cambridge University Press.

Hillier, B. (2008). Space and spatiality: what the built environment needs from social theory. *Building Research & Information*, *36*(3), 216-230.

Hillier, B., Burdett, R., Peponis, J., & Penn, A. (1987). Creating life: Or, does architecture determine anything? *Architecture & Comportement/Architecture & Behaviour*, *3*(3), 233-250.

Hillier, B., & Hanson, J. (1984). *The social logic of space*. Cambridge university press.

Hillier, B., & Vaughan, L. (2007). The city as one thing. *Progress in Planning*, *67*(3), 205-230.

Hillier, W., Yang, T., & Turner, A. (2012). Normalising least angle choice in Depthmap-and how it opens up new perspectives on the global and local analysis of city space. *Journal of Space syntax*, *3*(2), 155-193.

LaFlair, G. T., Egbert, J., & Plonsky, L. (2015). A practical guide to bootstrapping descriptive statistics, correlations, t tests, and ANOVAs. *Advancing quantitative methods in second language research*, 46-77.

Liao, K., Wehrhahn, R., & Breitung, W. (2018). Urban planners and the production of gated communities in China: A structure–agency approach. *Urban studies*, 0042098018801138.

Mehaffy, M. W., Porta, S., & Romice, O. (2015). The “neighborhood unit” on trial: a case study in the impacts of urban morphology. *Journal of Urbanism: International Research on Placemaking and Urban Sustainability*, *8*(2), 199-217.

Peponis, J., Hadjinikolaou, E., Livieratos, C., & Fatouros, D. A. (1989). The spatial core of urban culture. *Ekistics*, 43-55.

Rofe, Y. (1995). Space and community-the spatial foundations of urban neighborhoods: An evaluation of three theories of urban form and social structure and their relevance to the issue of neighborhoods. *Berkeley Planning Journal*, *10*(1).

Shen, Y., & Karimi, K. (2017). The economic value of streets: mix-scale spatio-functional interaction and housing price patterns. *Applied Geography*, *79*, 187-202. https://www.sciencedirect.com/science/article/pii/S0143622816308293

Tedong, P. A., Grant, J. L., Wan Abd Aziz, W. N. A., Ahmad, F., & Hanif, N. R. (2014). Guarding the neighbourhood: The new landscape of control in Malaysia. *Housing Studies*, *29*(8), 1005-1027.

Vaughan, L. (2015). High Street Diversity. In L. Vaughan (Ed.), *Suburban urbanities: Suburbs and the life of the high street* (pp. 153-174). UCL Press. https://www.jstor.org/stable/j.ctt1g69z0m

Yue, Y., Zhuang, Y., Yeh, A. G., Xie, J. Y., Ma, C. L., & Li, Q. Q. (2017). Measurements of POI-based mixed use and their relationships with neighbourhood vibrancy. *International Journal of Geographical Information Science*, *31*(4), 658-675.

Zhao, W., & Zou, Y. (2017). Un-gating the gated community: The spatial restructuring of a resettlement neighborhood in Nanjing. *Cities*, *62*, 78-87. https://doi.org/10.1016/j.cities.2016.12.015