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Housing Layout Design

– neighbourhood morphology, pedestrian movement, and strategic choices

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This article reports concisely a study of some Swedish and Chinese built neighbourhoods. Major issues explored include the description and comparison of neighbourhood spatial morphologies, the relation between spatial structures and patterns of pedestrian movement, and, the significance and possibility in turning spatial pattern per se into a well-defined problem of housing layout design.

THE NEIGHBOURHOOD UNIT is a housing planning idea which has long been practiced around the world (Perry, 1929; Dahir, 1947; Stein, 1957; Goss 1962; Tetlow & Goss, 1968; Franzén & Sandstedt, 1981; Dong, 1987; Wu, 1989). However, although housing layouts designed as the neighbourhood unit are often believed to have implications for human contact and community formation, the *very spatial pattern*, or *morphology* of the planned neighbourhood, is nevertheless an architectural phenomenon which seems to have been barely touched by architectural research (Klarqvist, 1986), let alone the potential or actual implications of different spatial patterns for residential life. By neighbourhood unit I refer specifically to an urban area developed for housing purpose and organized more or less in accordance to the principle of neighbourhood unit planning, i. e. it is seen as purely a spatial enclave or plan entity; even though the physical boundaries as set by planning arbitrarily for such an enclave may in reality not always agree with those of a socially defined neighbourhood.

What, is the fundamental strategic difference between one neighbourhood spatial pattern and another, in terms of residential culture and function? How can, neighbourhood plans of great morphological dissimilarity be analyzed and compared so as to inform design? Moreover, are there any spatial principles which may allow us to approach housing design at the level of overall layout or structure, over and above those which are formulated for dealing with more specific, programmatic functions? These, I suggest, are some of the questions which

research will have to clarify if our design knowledge is to advance.

The physical structure of a neighbourhood, if seen primarily in land use terms, for example, may be always described as composed of a few principal plan elements: dwelling houses, shops and communal facilities, green and play areas, and finally a continuous network of streets and paths of varying characters. How are these physical elements juxtaposed and articulated in relation to each other, normally creates the kind of spatial pattern which we recognize as well as experience as unique to a neighbourhood. But to say that the spatial pattern of a neighbourhood is essentially brought about by the arrangement of its principal plan components, is one thing; to proceed also trying to take a grasp of its morphological complexity for research purpose, could be a far more intriguing thing. Figure 1 is a sample of Swedish and Chinese urban housing areas built since the early 1950s, whose great morphological diversities may have provided a telling case for illustrating the point here.

Description of plan geometries, for example, can help us characterize these neighbourhoods in some way. However, a description of such purely compositional aspect obviously could not lead us to a better understanding of the fundamental similarities or differences among these neighbourhoods, in terms of overall spatial pattern and its social implication. On the other hand, a description of features like dwelling types, traffic systems, building density and population density, and the provision of communal facilities or amenities, may enable us to grasp some of the cultural similarities and differences among these built forms. But even an analysis of these gross features with respect to some background conditions, in my view, tends to miss the functional and cultural nature of the spatial patterns of these neighbourhoods entirely. For although given some explicitly discussible design constraints and principles (*Bostadens grannskap*, 1972, 1975; Tongji, 1981), it is usually possible for us to describe and compare among different layout solutions in terms of specific functional performances, at the level of overall spatial pattern, it is apparent that we do not possess the kind of knowledge which also allows us to clarify fundamental strategic differences between one complex plan design and another.

In this paper, an attempt is made to explore whether the overall spatial morphology of the planned neighbourhoods has any broad relevance to aspects of residential life, and, should it have, to how far we can make that dimension itself a well-defined issue of design. The space syntax method (Hillier & Hanson, 1984; Hillier et al., 1987b) is the major analytical tool used in the exploration. The study is carried out according to a procedure which is presented here roughly in three parts.

In the first, space syntax technique for settlement analysis is applied to a cross-cultural sample of neighbourhoods to search for any broadly comparable configurational properties. The basic assumption behind the exercise is that, given that housing design is an activity which is both informed and overtly determined by social cultural conditions, if some morphological properties of broad comparability can be found from a highly heterogeneous sample of cases, then these properties may be also considered as the significant ones for understanding these neighbourhoods as a particular class of layout designs.

In the second part, a set of field studies is then made of sample neighbourhoods to decide whether their spatial morphologies have any describable and systematic relation to patterns of pedestrian movement, and whether different morphologies make a difference in affecting the density and distribution of movements, using the outcome of the preceding analysis as some guiding hypothesis. The underlying assumption here is that if certain syntactic properties can be shown as crucial to the spatial formation of the heterogeneous sample of cases, then they may prove to be also relevant to the ways in which pedestrian spaces are used in these neighbourhoods.

Finally, key findings as brought about by the two preceding studies are used as some point of

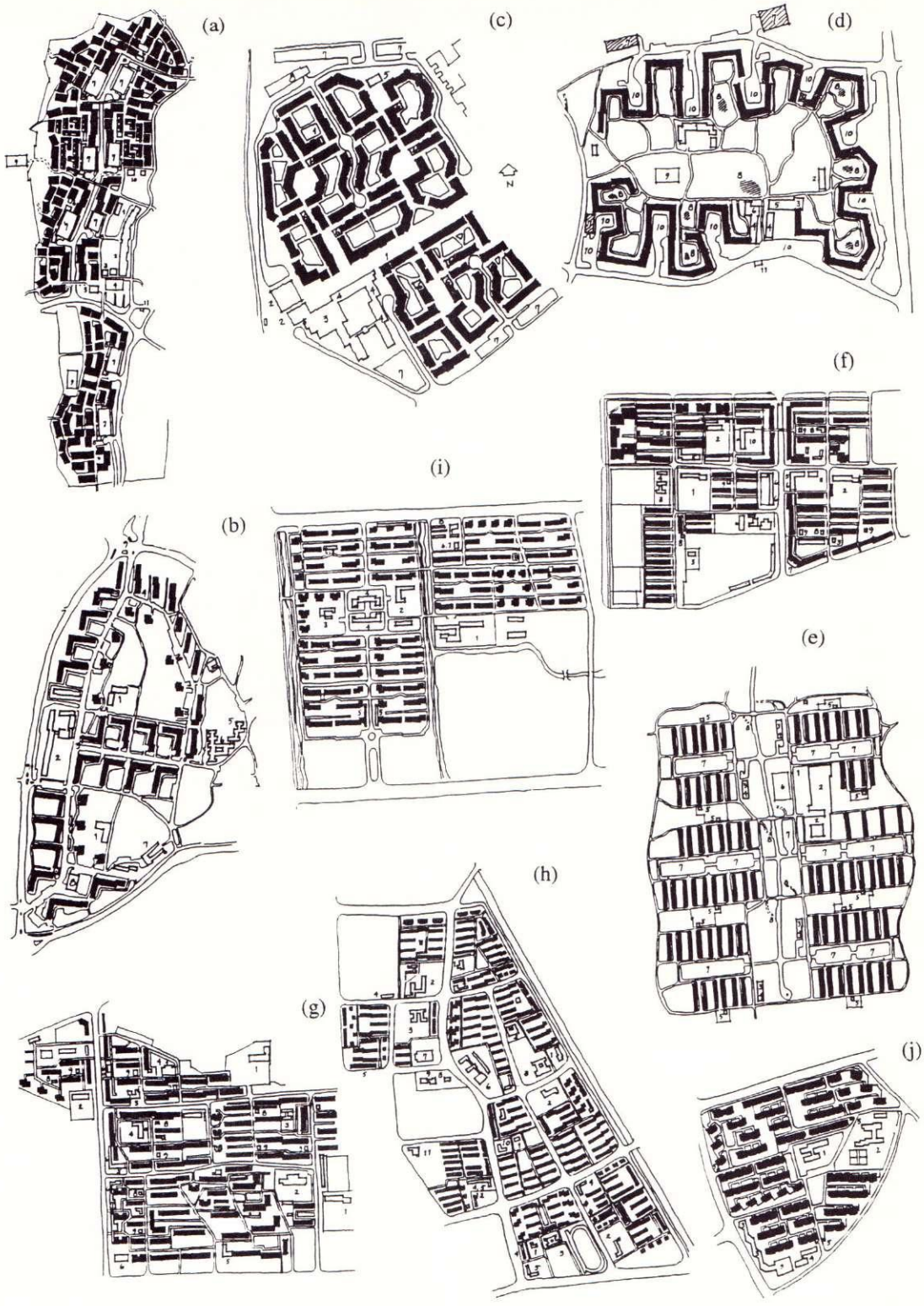


Figure 1. Sample neighbourhoods, site plans: (a) Skintebo; (b) Kyrkbyn; (c) Dalen; (d) Baronbackarna; (e) Brickebacken; (f) Tuanjiehu North; (g) Tuanjiehu South; (h) Tiyuanbei; (i) Caixiancun; (j) Hutai.

departure to try and establish the spatial dimension per se as an object of purposeful design intervention. This leads to the formulation of a few strategic choices which are suggested as potentially relevant to future housing design.

Spatial analysis of neighbourhood layouts

Sample neighbourhoods: some manifest features

The sample of built neighbourhoods used in this present study includes five Swedish cases and five Chinese cases (see Fig. 1). Among the Swedish neighbourhoods, three are selected from large cities, two from a medium-sized town. While all but one Chinese cases are from large cities.

There are some basic features which the ten neighbourhoods seem to be sharing in common. First, judged by the kind of criteria we commonly employ to define a planned neighbourhood, namely, an urban area which is developed primarily for residential purpose, and equipped with a few communal facilities essential to the daily life of the local inhabitants of the development, all but one (Case *h*) of the cases can be roughly classified as neighbourhoods. Next, except in cases where existing land use patterns exerted certain restrictions upon their site plan formation (Cases *f* and *g*), the majority of these neighbourhoods are organized more or less spatially demarcated from their surroundings, either by natural boundaries such as canals and natural lands, or by urban arteries and highways. Third, except one case (Case *h*), these neighbourhoods are also designed to have some local street systems, as distinguished from the surrounding ones.

Except for the few broadly comparable aspects, the physical features of these neighbourhoods differ in many other aspects in a marked way. First, the areal sizes of the ten cases vary within a broad range. Second, the dwelling types of these neighbourhoods also differ from each other widely, ranging from single family, low-rise terraced houses to multi-family, medium- and high-rise apartment houses. Third, although according to street layout principles, it seems that these neighbourhoods could in general be classified into three types – i. e., those featuring a "central-approach" vehicular road; those possessing a "peripherial-approach" vehicular road; and those having a street network intended for "mixed-use", at a more detailed level, none of these neighbourhoods can be identified with one another. Fourth, although according to the location of communal facilities, roughly two general tendencies can be identified – i. e., "concentrated" respective "decentralized" arrangements, as far as the exact location of these facilities is concerned, each neighbourhood more or less can be regarded as unique. Finally, the most striking variety as displayed by the sample of neighbourhoods is no doubt reflected in their overall spatial patterns, or, to be more exact in the ways in which the dwellings are grouped together and the patterns of street (pedestrian) systems arising from these groupings.

How, can the great plan differences as displayed by the sample of neighbourhoods be described and analyzed so as to permit comparison among their layout patterns, therefore, poses a difficult problem which this study first had to deal with, before we can raise any questions about the relation of neighbourhood spatial dimension to observable patterns of space use. I tried to overcome this difficulty through analysis exercised at the level of spatial configuration.

Syntactic analysis: questions and procedure

A syntactic analysis of the sample neighbourhoods aimed above all at identifying configurational properties which may permit construction of a spatial typology of these neighbourhoods. This among the others meant that it had to find some answers to the following two questions: (1) given its manifested geometrical diversity, are there any underlying configurational properties characteristic of the sample as a whole? (2) are there any syntactic patterns which also permit the differentiation of some

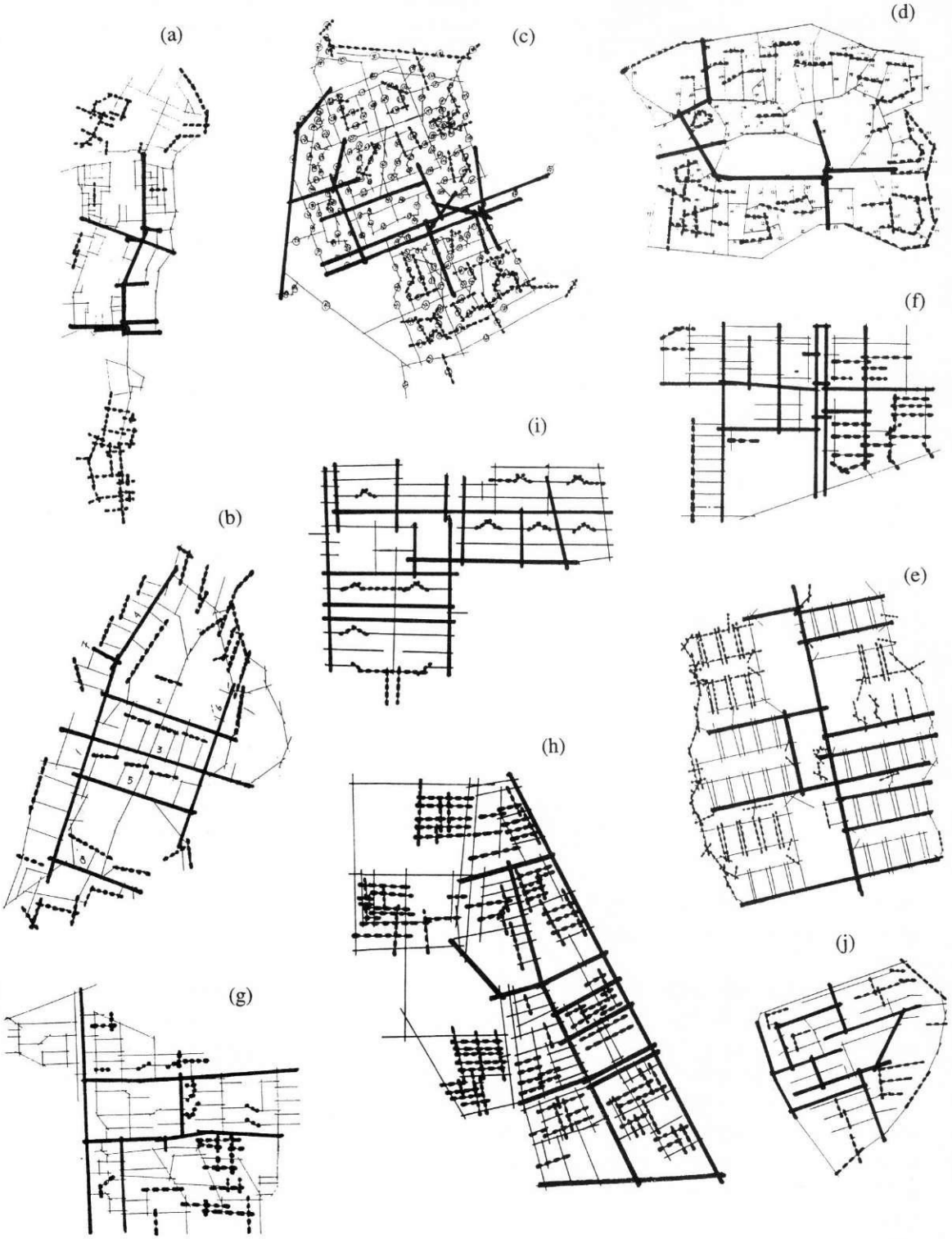


Figure 2. Maps showing the integration structures of sample neighbourhoods: (a) Skintebo; (b) Kyrkbyn; (c) Dalen; (d) Baronbackarna; (e) Brickebacken; (f) Tuanjiehu North; (g) Tuanjiehu South; (i) Tiuyanbei; (i) Caixiancun; (j) Hutai.

Neighbourhood	*Size*	*mean RRA*	*Core Space*	*%*	*Seg Space*	*%*
Case *a*	171	1.112	12	7.0%	100	58%
Case *b*	110	.692	8	7.3%	64	58%
Case *c*	197	.836	14	7.1%	113	57%
Case *d*	172	1.047	8	4.7%	96	56%
Case *e*	199	.666	14	7.0%	117	59%
Case *f*	81	.840	5	6.2%	45	56%
Case *g*	122	.926	9	7.4%	66	54%
Case *h*	200	.714	14	7.0%	116	58%
Case *i*	80	.840	6	7.5%	47	59%
Case *j*	65	1.12	5	7.7%	38	58%
Average		.879 (.256[a])		6.9%		57%

a. Pearson's correlation coefficient calculated for neighbourhood sizes (in total number of axial lines) and overall integrations.

Table 1. The size, mean integration, number of core spaces, and number of 50% segregated spaces of all Swedish and Chinese cases.

Neighbourhood	Size	*CN:RA*	*CV:CH*	*CN:CH*	*RA:CH*	*10% INT:CH*
Case *a*	171	-.376	.728	.836	-.417	.823
Case *b*	110	-.574	.901	.951	-.669	.832
Case *c*	197	-.547	.637	.814	-.688	.638
Case *d*	172	-.528	.537	.714	-.717	.860
Case *e*	199	-.399	.781	.854	-.477	.939
Case *f*	81	-.361	.574	.650	-.808	.565
Case *g*	122	-.548	.611	.802	-.720	.679
Case *h*	200	-.562	.656	.859	-.738	.808
Case *i*	80	-.598	.694	.895	-.717	.620
Case *j*	65	-.606	.743	.858	-.688	.758
Average		-.510	.687	.823	-.664	.752

Table 2. The size, correlations between the four basic syntactic measures, and correlation between the integration values and choice values of spaces constituting the integration core of all Swedish and Chinese cases.

"type structures" within the sample? The analysis was carried out in the following procedure.

First, four syntactic measures (*connectivity, integration, global choice and control*) were applied to the modelling of the axial organizations of these neighbourhoods; the ways in which these measures are distributed among the constituent spaces of each neighbourhood were examined searching for patterns suggesting typical spatial structures, especially the global (*integration* and *choice*) ones. The interrelations between the four measures and their relationship to a few other layout features were then explored using simple statistical techniques, focusing on any trends of variation and co-variation within the sample.

Common properties

A comparison of the integration patterns among the ten cases immediately reveals some interesting configurational tendencies. Both the Swedish and Chinese neighbourhoods, as shown in Figure 2, seem to have characteristic integration structures, represented above all by the patterning of the "integration cores" of their axial systems. Out of the ten neighbourhoods, for example, Cases *a, c*, and *d* are found to possess integration cores which typically take the form of a series of lines coupled to shorter,

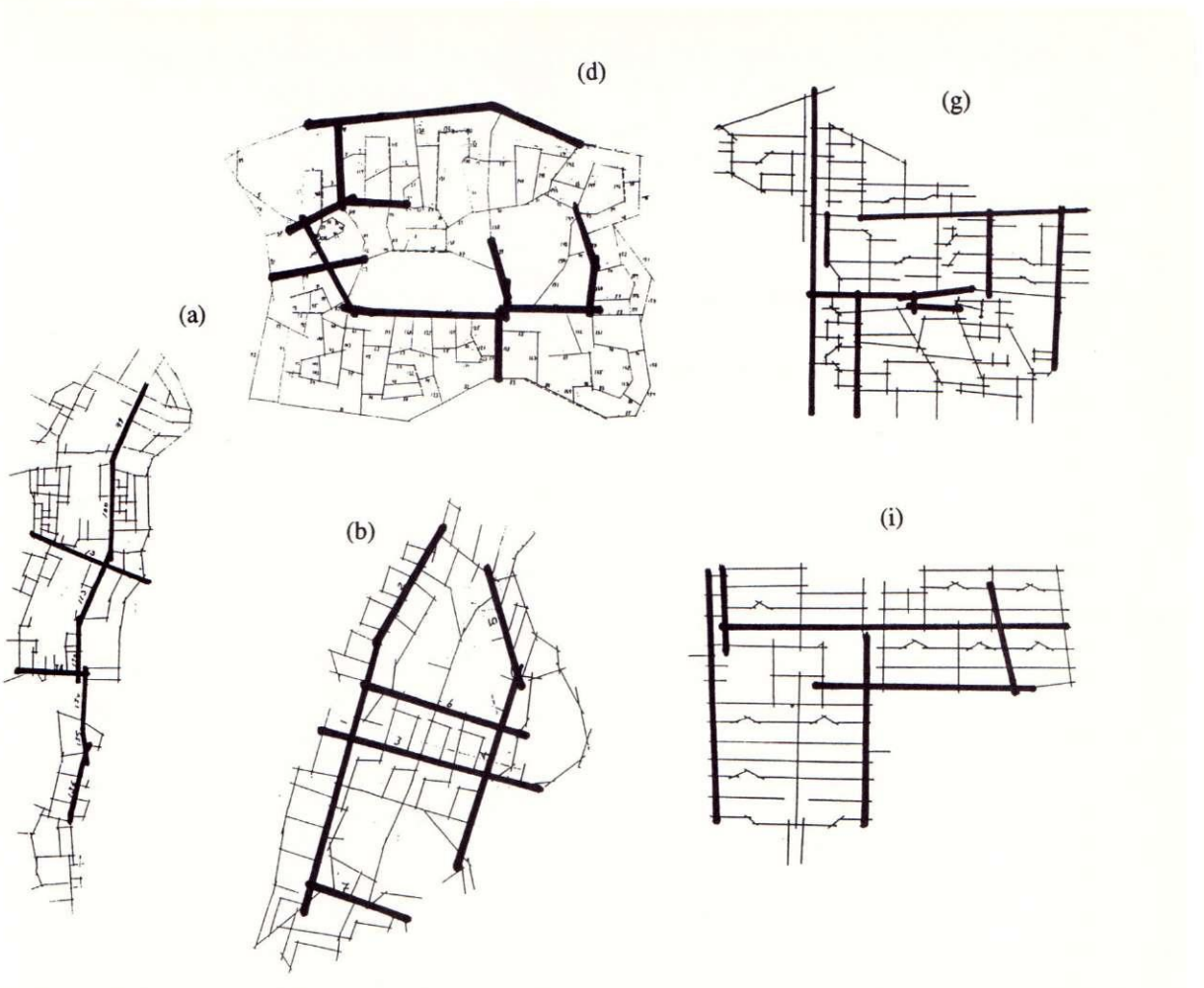


Figure 3. Maps showing the global structures of some of the neighbourhoods: (a) Skintebo; (b) Kyrkbyn; (d) Baronbackarna; (g) Tuanjiehu South; (i) Caixiancun.

branching parts, i. e., cores which are made up by a cluster of strong integrating lines extending more or less in "linear" shape inside an axial system. Meanwhile the rest of the sample except Case *j* appear to possess cores which tend to be either unfolding themselves from the centre of a system into the different parts of that system, or embracing a system from both its inner area and peripheries, i. e., cores which resemble more or less a grid, or "deformed-wheel" (Hillier et al., 1987a).

The sample as a whole, also exhibits some trends concerning the patterning of the global choice property of a plan system. Figure 3 presents the axial organizations of some of the cases, with the distribution of their top 25% global choice values (core) indicated. Examined intuitively, we can already identify a high degree of overlapping between the integration and choice cores among these neighbourhoods (cf. Fig. 2). And equally suggestive feature indicating some other patterning tendency, can be found in the way in which the global choice cores of these neighbourhoods are distributed in relation to all parts of an axial system, as compared with that of integration.

In order to find out if there are other common configurational properties within the sample, I explored the statistical data of the ten cases (*Table 1* and *Table 2*). Described in brief, the over-

all integration of a neighbourhood is found as having no significant relationship with its size. On the other hand, both the number of axial spaces which account for the top 10% of total integration values of these neighbourhoods (except Case *d*), and the number of axial spaces making up the lower 50% of total integration value, appear to have a remarkably strong relation with the size of their axial systems (cf. *Table 1*).

A further analysis of these data, however showed that the most suggestive clues about the sample as a whole seem to be embodied by the inter-relations among basic syntactic measures (cf. *Table 2*). Since throughout the ten cases, there is found a strong correlation between the connectivity and global choice properties of neighbourhood axial systems (r = .823 calculated for the whole sample); a relatively strong correlation between control and global choice (mean r = .687); and a moderate correlation between connectivity and integration (mean r = -.510). The two global properties (i. e. integration and global choice), then, are also found to correlate with each other moderately strongly throughout (mean r = -.664). Besides, if it is spaces which constitute the integration core of a system only which are to be counted, the correlation between these two measures tends to become even stronger (mean r = .752).

To make sure if these general trends are really some representative ones for the sample as a whole, I also explored the statistical data by further dividing our cases into two groups according to their respective cultural identities and comparing their statistical profiles. However, despite the considerable cultural and layout dissimilarities between the two groups, it was found that there in effect exists a clear similarity between the statistical pictures of both groups, reflected especially in the consistency of the rank order in the correlations between the local and global measures of these neighbourhoods.

Type structures

While an analysis of the patterning of key syntactic measures and their inter-relations has led us to identify essential similarities, it has at the same time also revealed features pointing to configurational differences. First, as far as the integration dimension is concerned, it appears that at least two "type patterns" or "type structures" can be differentiated among the cases according to integration cores. The one of these, as mentioned earlier, typically feature an integration core which tends to cluster in the central part of a neighbourhood in a more or less linear manner (see Fig. 2). By far the purest form of this structure is exemplified by Case *d* (Baronbackarna). One near-variant is found in Case *a* (Skintebo). Another near variant can be found in Case *c* (Dalen). The other of these, as also mentioned earlier, tends to have a deformed-wheel-like integration core. The most typical manifestation of this structure is found in Case *b* (Kyrkbyn) and Case *i* (Caixiancun). One near variant of the structure is exemplified by Case *f* (Tuanjiehu North) (see Fig. 2).

Second, in addition to the patterning of the integration cores, the syntactic structures of the cases are also found to differ from each other in the co-variation between the four syntactic measures. In terms of the degree of overlapping between the integration and global choice structures of a plan system, for instance, at least two more type structures can be isolated. One of these structures, as exemplified by Cases *a*, *b*, *d* and *e* (cf. *Table 2*), tends to have a fairly strong, overlapped relationship between top integration and global choice values among the few core spaces of a system but a relatively weaker correlation between the two measures for the system as a whole. The other is one in which a strong correlation between the integration and global choice measures for a whole system tends to be associated with an equally strong or less stronger agreement between the two measures among the core spaces, as exemplified by Cases *f*, *g* and *i*.

To sum up, an analysis of the sample of Swedish and Chinese neighbourhoods using space syntax technique appears to have yielded some novel and interesting facts about their spatial

morphologies. Regardless of substantial cultural and geometrical dissimilarities, both configurational properties which are distinctive to the sample as a whole, and syntactic patterns which suggest trends towards certain type structures, have been revealed. More specifically, two syntactic properties – i. e. integration and global choice, and the measure of connectivity-global choice correlation, are found to be the fundamental ones for understanding the spatial morphology of these neighbourhoods.

Given the questions as posed by this present study, these findings thus seem to have important implications for our later explorations. First, the identification of some broadly comparable properties from a heterogeneous sample of neighbourhoods, seems to be suggesting that in addition to being decided by cultural and other known constraints, the spatial patterning of these neighbourhoods is also governed by few configurational principles which are until now unknown to us; though whether these principles are ones "implied" by design parameters we commonly apply to a housing layout or something existing in their own right, is a question yet to be answered through more extensive studies. Second, the finding of these properties enabled us to build a spatial typology of our cases, which can be consistently related to some observed patterns of space use to explore the relevance of neighbourhood spatial morphology to, e. g. aspects of social life.

Neighbourhood morphology and pedestrian movement

Procedure of analysis and questions

A study of the relation of neighbourhood spatial morphologies to patterns of space use started by selecting a sample of axial spaces from a neighbourhood to form an observational route to include all kinds of pedestrian spaces. A walking observer then moved along these routes while recording people passing by him or her on each walk-round; at least twenty rounds of observation were made for each neighbourhood. The numbers of moving people as recorded for these sample spaces (expressed as *encounter rates*) were then statistically correlated to the syntactic measures. All together three pairs of correlations were computed for each neighbourhood, describing the degree of association between the *integration*, *choice*, and *control* properties and the density of pedestrian movement as observed.

Comparing among the cases, I raised two major questions to the statistical data. The first of these is, if there are certain configurational properties which are found as crucial to the patterning of neighbourhood layouts, to how far can these properties be also regarded as relevant to the way the pedestrian spaces of a neighbourhood are actually used? Answer to this question, however, is given by exploring each of the following three sub-questions: (1) among the three spatial measures used to describe neighbourhood layouts, which one is more strongly correlated with the density of movement? (2) are these measures working in concert in all neighbourhoods, or do they tend to be working in different ways? and, (3) given that people usually move about in a neighbourhood with different (functional) localities as their destinations, to how far can the layout per se be considered as a relevant variable in affecting movement should some strong correlations between syntactic properties and patterns of pedestrian movement emerge? The second major question is, if the ways in which pedestrian movements were distributed in relation to syntactic properties can be shown as varying from case to case throughout the sample, to what extent can such differences be explained by the morphological differences between neighbourhoods?

General trends

Table 3 presents statistical data most relevant to exploration of our questions. A brief examination of the table however shows that the mean density of movement as found in each neighbourhood by and large has no apparent connection to the mean integration (mean RRA) of each

Neighbourhood	*mean RRA*	*mean ENC*	*1/RA:ENC*	*RGC:ENC*	*CV:ENC*
Case *a*	1.112	.55	.482	.707	.405
Case *b*	.692	.92	.709	.797	.814
Case *c*	.836	.58	.427	.457	.267
Case *d*	1.047	.22	.325	.292	.032
Case *e*	.666	.37	.502	.467	.208
Case *f*	.840	3.6	.844	.861	.496
Case *g*	.930	4.3	.733	.737	.719
Case *h*	.714	3.2	.607	.662	.806
Case *i*	.840	2.8	.767	.665	.260
Case *j*	1.120	4.1	.582	.613	.269

Table 3. The mean integration, observed overall density of movement (mean ENC), and correlations between encounter rates and spatial variables of all neighbourhoods.

axial system. On the other hand, it appears difficult to identify from the table features also suggesting trends of co-variation between the three key syntactic properties and density of movement. In order to clarify this essential issue, I examined the three pairs of correlations one by one.

Table 4 summarizes the correlation of density of pedestrian movement with integration in all neighbourhoods by grouping these correlations into four value intervals. As the table shows, among the ten cases, in at least five the measure correlates strongly or relatively strongly with density of movement. It associats moderately strongly with movement in four other cases. It is only in one neighbourhood the correlation is rather weak.

However, while the integration measure is found to have a relatively strong relation with movement density in at least half of the cases, further scrutiny of data shows that the global choice in effect correlates even better with density of movement (*Table 5*), since out of the ten cases, in seven this measure correlates with encounter rates strongly or moderately strongly. Besides, it is also found that whenever this measure does not produce the best result it gives the second best correlation. The control property of neighbourhood layouts, on the other hand, is found to have the most uncertain relationship with the density of movement. For while the measure is found to correlate with movement density fairly strongly in two neighbourhoods, it has at the same time also produced the weakest correlations in five of the ten cases, as compared with integration and choice.

A comparison between the data of *Table 4* and *Table 5*, then, reveals some interesting features which may partly answer the second sub-question as posed before. Allowing some variations, in nine cases the integration and global choice measures are found to correlate almost equally strongly with movement density regardless of differences between the nine pairs of values.[1] In other words, whenever one of these measure correlates with movement density strongly (or less strongly), the other tends to covary with density according to an almost equally linear (or less linear) pattern.

Finally, I explored the third sub-question raised early through comparing between the ways in which communal facilities are located in individual neighbourhoods and their statistical profiles. The results, however seem to be suggesting that the density and distribution of pedestrian movements in neighbourhoods tend to co-vary with spatial structures regardless of how major communal facilities are distributed.[2] Both Case *b* and Case *d* (Kyrkbyn and Baronbackarna respectively), for example, are neighbourhoods in which a roughly similar principle is adopted for locating the communal facilities – i. e., almost all the shops and miscellaneous services of a neighbourhood are grouped together to form a local centre which is in turn placed on one side of that neighbourhood (see Fig. 1). But the integration measures of the two neighbourhoods, as we can see from *Table 4*, correlate with

Correlation coefficient r				
Strength	$r < .4$	$.4 < r < .6$	$.6 < r < .8$	$.8 < r < 1.0$
Strong				Case *f*
Moderately strong			Case *i* Case *g* Case *b* Case *h*	
Moderate		Case *j* Case *e* Case *a* Case *c*		
Weak	Case *d*			

Table 4. Correlation of movement density with integration; cases are ranked according to the strength in which the reciprocal of RA values are associated with encounter rates.

Correlation coefficient r				
Strength	$r < .4$	$.4 < r < .6$	$.6 < r < .8$	$.8 < r < 1.0$
Strong				Case *f*
Moderately strong			Case *b* Case *g* Case *a* Case *i* Case *h* Case *j*	
Moderate		Case *e* Case *c*		
Weak	Case *d*			

Table 5. Correlation of pedestrian movement density with choice; cases are ranked according to the strength in which RGC values are associated with encounter rates.

encounter rates in markedly different ways (r = .709 and .325, respectively). Case *g* and Case *i* (Tuanjiehu South and Caixiancun respectively), on the other hand, are two neighbourhoods in which entirely different principles are adopted for the location of facilities. The former has no large service centre whatsoever; while the latter is organized such that a local centre incorporating a variety of facilities is formed and placed in the middle of its central axis (see Fig. 1). Despite this apparent layout difference, almost the same strong linear associations between integration and movement were found in the two cases.

Predicting movement from syntax: variability

However, whereas some general trends were found for the sample as a whole, we can also see that there clearly exist certain variability in the correlational patterns obtained from individual neighbourhoods. I therefore tried to find some answer to the second major question raised to correlational study by exploring the syntactic structure of each case while keeping an eye on those correlational patterns. I examined the integration dimension first.

Case *f* (Tuanjiehu North) is a neighbourhood whose integration property is found to correlate best with movement density among all the cases (cf. *Table 4*). A review of its spatial profile shows that this neighbourhood possesses a typical wheel-like integration core. Cases *b*, *g*, *h*, and *i* (Kyrkbyn, Tuanjiehu South, Tiyuanbei and Caixiancun), which all belong to the category of neighbourhoods whose integration structures correlated relatively strongly with densities of movement, then appear also to have integration cores which resemble more or less a deformed-wheel (see Fig. 2). On the other hand, among the other five cases in *Table 4*, whose integration properties correlate with movement density either weakly or only moderately, three are identified as possessing linear integration cores (Skintebo, Dalen and Baronbackarna), one is found being attributed with an integration core which is almost entirely confined to the inner area of the neighbourhood (Hutai).

A reexamination of the global choice dimension, then, led me to find out that although this property is found to correlate best with movement density among all three spatial measures, the strength with which this measure correlates with the density of pedestrian movement could be made to fluctuate by what might be called the "distorting effect" of certain spaces in a plan system, depending on the degree of agreement between the global choice values of these spaces and their actual significance for "through-movement" within that system.

Finally, although both the integration and global choice properties of sample neighbourhoods are found to have observable relation to pedestrian movement, in more than two third of the cases, relatively biased, or "polarized" patterns of movement distribution in relation to these measures are also disclosed. In other words, other conditions being equal, the "syntactic cores" of the neighbourhoods tended to draw most of the pedestrian movements to them, thereby sharply reducing the densities of movements in spaces with medium and low syntactic values.

Tentative conclusions

In the light of the above facts, we may say that a morphological study of the sample of built neighbourhoods seems to have produced revealing results. Summarized, following statements can be made to bring its key findings into focus.

• In seven out of ten cases there is a strong or moderately strong correlation between *global choice* and encounter rates; meanwhile in at least five cases *integration* is found as correlating strongly or moderately strongly with encounter rates. By and large, encounter rates are predictable from spatial morphology in all Chinese examples but only in a minority of Swedish cases.

• There is preliminary evidence suggesting that distribution of pedestrian movement in the neighbourhoods is more related to the syntax of layouts than to the location of particular land uses. Neighbourhoods with similar layout strategies for the location of non-residential uses display different correlations while neighbourhoods which display similar correlations are designed according to different strategies regarding non-residential land use location.

• There is a clear pattern of association between the presence of deformed wheel cores and the occurrence of strong correlation between syntactic variables (integration) and encounter rates. Roughly, in five out of six neighbourhoods with a deformed wheel core there is found a strong correlation between integration and encounter rates.

These findings, thus in part supply evidence suggesting that, within the confine of our sample, the spatial dimension of the planned neighbourhoods seems to have an observable relation to patterns of pedestrian movement. This confirms once again the fundamental syntactic theorem already amply demonstrated by research, namely, the distribution of pedestrian movement in the urban areas is a function of the space syntax of layouts (Hillier et al., 1987b; Peponis, 1989).

What specific implications, then, does a clarification of the above facts have for design? One immediate implication, obviously, is that strategic layout decision in housing design does seem to have a bearing on aspects of residential life. According to the space syntax theorem, through generating pedestrian movements of varying densities, the spatial structure of an urban area at once creates in that area *a field of probabilistic encounter*, thereby also bringing life to the different parts of that area. (Hillier et al., 1987b; Hillier, 1989). This, in turn means that, if so wished, the overall spatial layout of a large housing development could be manipulated by design to attain certain desirable (social) goals – among others to assist creating the kind of backgorund condition which will permit "maximum choice" in the voluntary or involuntary (visual) contacts among people staying and moving about in a residential area (Gans, 1961).

How, and in what way, then, can the spatial dimension be approached by design in order to obtain some desirable goals? Drawing upon the insights I have gained from the above reported survey, I suggest that, if the patterns of movement in the neighbourhoods can to a varying degree be influenced by the morphology of layout which is capable of rigorous analysis, then there seems to exist a number of different ways to approach housing layout design so as to attain these goals. To formulate some strategic design choices possibly relevant to future housing decision-making through studying the built form, as I will describe in next section, is one thing which we can do to turn the spatial dimension

itself into an issue of socially-aimed housing design.

Some strategic choices for future housing design

To formulate some strategic choices potentially relevant to future housing design through studying the built form, put it simply, is to look at the built neighbourhoods in a normative manner, and to try and recognize from their plan patterns some morphological structures which may suggest interesting solutions to particular design problems. Such structures may arise from individual circumstances without the designers' awareness. However, once revealed by analysis, they may in turn prove to be also capable of design manipulation, thereby making socially-aimed urban design a knowledge-based intellectual activity.

Suppose, that in addition to satisfying the kind of programmatic functions commonly required by large housing developments, one of the major aims of a new housing development is to adapt the spatial design of these functions to the syntactic structure of a layout to bring about some desirable patterns of encounter. What different strategic choices do we have when being confronted with particular design problems? Below I wish to use three examples to explore and demonstrate how we can make a syntactic analysis of neighbourhood layouts serve that purpose.

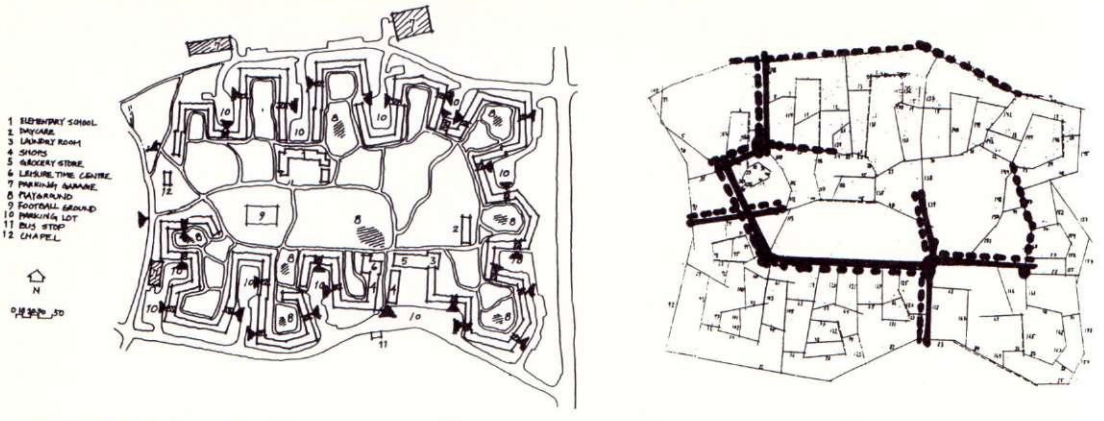
Spatial structure and neighbourhood entry

One important decision which any new housing development will have to make at its initial stage of design, we may say, is concerned with the design of its traffic system. And different layout solutions adopted for differentiating between the vehicular and pedestrian traffic, usually can have different consequences for traffic safety and access. Complete traffic separation, for example, normally implies a greater degree of safety and less disturbance to the residents of a neighbourhood, but the desire to keep the motor vehicles entirely outside the pedestrian zone, could also mean limited accessibility to certain localities. On the other hand, in a street system where traffic separation and differentiation is only partially implemented, both the motor vehicles and the pedestrians may have greater access to the inner area of a neighbourhood, but such a system could also generate conflicts between the two kinds of traffic and cause bigger nuisances in terms of noise and exhaust. Design of traffic systems in a large housing development, in the most circumstances thus has to choose between the two basic solutions with respect to different priorities. While the extent to which a neighbourhood design can be said to be successful or not, can be judged partly by its street layout design in terms of satisfying requirements upon safety and access.

But suppose we already possess the kind of knowledge for designing traffic systems which by and large assures the above mentioned qualities, if one of the basic aims of a new housing development is also to achieve some desirable patterns of space use and encounter, how can we attain this goal by means of layout design? To design the street entries of a development in relation to its (global) spatial structure, I suggest, could be one answer to this design puzzle. By street entry I mean, (a) pedestrian links between a local neighbourhood and its surrounding street network, and, (b) places where the vehicular system of a neighbourhood terminates and its internal pedestrian network begins.

Traffic separated systems

When the street system of a neighbourhood consists of a vehicular road system and a pedestrian sysstem, our experience tells us that some of the pedestrian areas of that neighbourhood usually become more densely used if they happen to be constituting zones where both systems meet – i. e., the *entry areas* of the neighbourhood. While some other parts of the neighbourhood would receive less use because quite a portion of movements taking place around those entry areas probably will never



Figures 4 a & b. Baronbackarna neighbourhood: (a) site plan, with pedestrian entries to the neighbourhood indicated; (b) axial map, with integration and choice cores indicated in heavy black respective dotted lines.

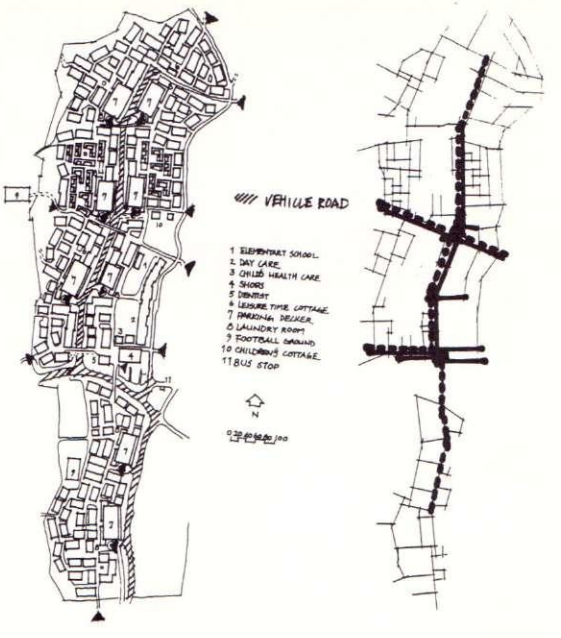
reach these parts. If a neighbourhood which happens to have its global structure (i. e. its integration core and choice core) distanced from most of its entries in terms of syntactic step, then it is likely that a rather dispersed distribution of movement will arise due to such a morphological relationship. On the other hand, if the global structure of a neighbourhood is to a large extent directly linked to its entries, then pedestrian movements potentially generated by that structure may become more predictable due to this direct connectedness. The relationship between the location of the pedestrian entries of a neighbourhood and its global structure, therefore, would mean a lot to patterns of encounter in terms of either channelling or instead dispersing movements along different directions.

Now, if the aim of a large housing development is to ensure maximum traffic safety and at the same time to make casual encounters among people moving around in its pedestrian network as dispersed or near random as possible, then the morphological choice suitable for attaining that goal, should be one which will always keep the global structure of the development as far away as possible from the majority of its entries. Figures 4 a & b are an analysis of the relation between entry location and global structure in one of our sample neighbourhoods (Baronbackarna), which seems to have supplied a near perfect example of what the proposed morphological choice should look like. Since, while being designed such that its inner area can be accessed from a large number of entries along its circumference, the neighbourhood is clearly attributed with a global structure which tends to distance most of the strong integrating and choice spaces from these entries.

However, if in addition to satisfying such requirements as accessibility and safety, it is also the aim of a housing development to make its pedestrian network a setting where encounter among people can be modulated and differentiated in finer gradation, then the morphological solution appropriate for this purpose should be one which will let most pedestrian entries of the development being either directly covered by its integration and choice cores, or located in places no more than two syntactic steps from strong integrating and choice spaces. Figures 5 a & b present the global structure-entry relationship in another sample neighbourhood (Skintebo), which seems to have exemplified the morphological choice formulated here. As shown, although strict traffic separation is implemented throughout this neighbourhood, most pedestrian entries from its parking areas and from a boundary street are directly linked to its integration core and choice core, thereby creating a series of interfacing zones where people moving around the entry areas and people passing by these areas will encounter more frequently.

Traffic mixed systems

When the street system of a neighbourhood is designed basically for mixed uses, it seems that denser pedestrian movements will arise more often on streets where mixture of vehicle and pedestrian traffics is more pervasive. But a concentration of pedestrian movements into few main streets like this, could also imply a biased distribution of encounters. If a neighbourhood happens to have its global structure overlapping largely with streets on which both vehicular and pedestrian traffics are allowed, then one direct consequence could be an over-concentration of pedestrian movements on these streets. On the other hand, if the global structure of a neighbourhood to a large extent happens to be confined to streets for pedestrian use only, while it is not quite distanced from those streets on which both vehicular and pedestrian traffics are allowed, then it is likely that pedestrian movements in that neighbourhood will become more predictable from syntax for most of the streets then for a limited few.



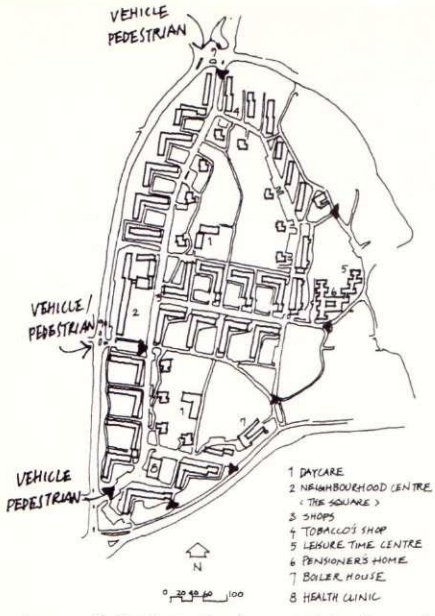
Figures 5 a & b. Skintebo neighbourhood: (a) site plan, with pedestrian entries indicated; (b) axial map, with integration and choice cores indicated in heavy black respective dotted lines.

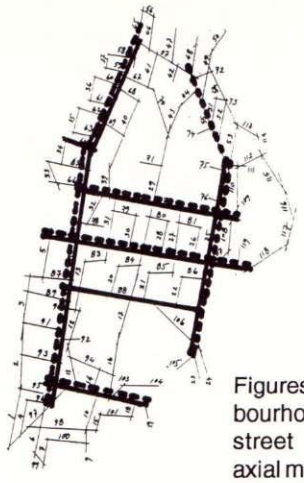
Suppose, then, one of the major aims of a housing development with mixed street system is to let the vehicular traffic make best use of its global structure and at the same time let that structure generate some desirable patterns of encounter. The morphological choice for achieving this is one which will make the global structure overlap as much as possible with its streets intended for mixed use. The neighbourhood (Kyrkbyn) presented in Figures 6 a & b is though not the most typical one but can still be used here for illustrating the proposed solution. Since while allowing some degree of traffic differentiation, the neighbourhood apparently is configured in such a way that almost all its vehicular accessible streets are covered by its integration and choice cores.

On the other hand, if the design priority of a mixed street system is to let its global structure generate pedestrian movements throughout the whole system in finely differentiated densities and at the same time keep the vehicular traffic being closely related to the main stream of such movements, then the spatial choice for attaining this goal could be one which will give as less as possible the global structure of a neighbourhood to streets of mixed use, and at the same time lets these streets be directly linked to that structure. Figures 7 a & b supply an interesting example which illustrates this alternative. As shown, while the main street of the neighbourhood is made one on which both vehicular and pedestrian traffics are allowed, the integration and choice cores of the neighbourhood appear to have got such a distributional pattern that they tend to cover the neighbourhood in all directions but only "intersect" with its main street here and there, thereby letting the pedestrian movements make the best use of the global structure and yet allowing the vehicular traffic to be closely related to the main stream of these movements.

Spatial structure and building entrance location

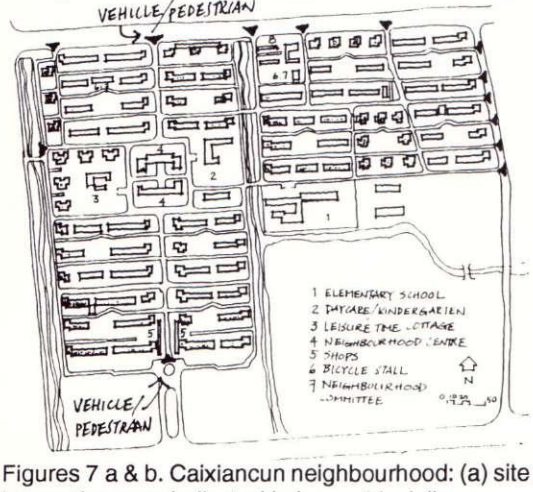
Another strategic decision which new housing developments also have to make at the early

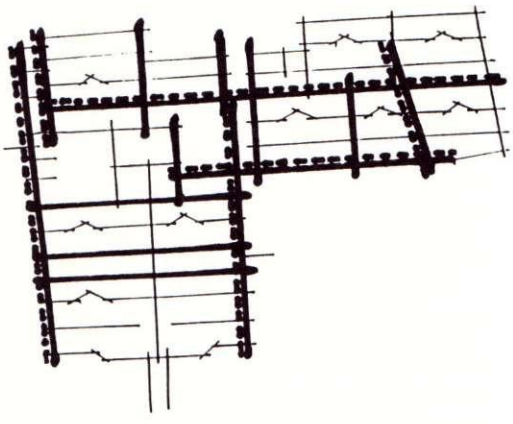




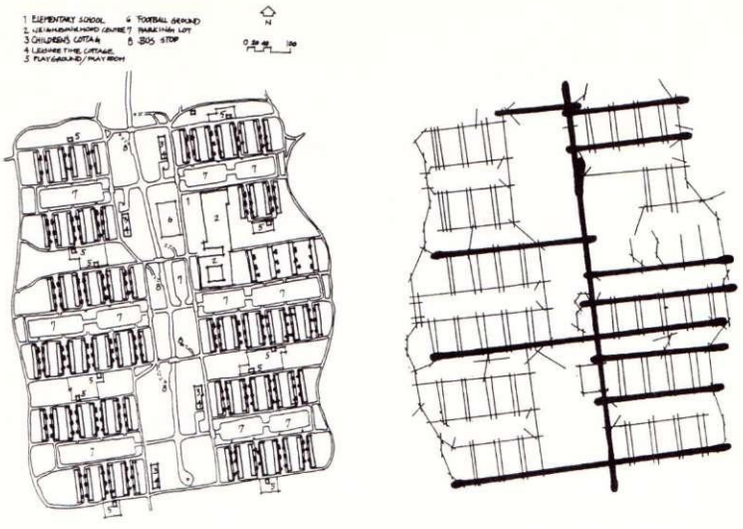
Figures 6 a & b. Kyrkbyn neighbourhood: (a) site plan, with street entries indicated; (b) axial map, with integration and choice cores indicated in heavy black respective dotted lines.

stage of design, is the positioning of building entrances in relation to pedestrian spaces. Whether the dwellings and service facilities in a housing area have their main entrances opening onto one kind of space rather than another, usually reflects different attitudes towards the kind of qualities to be created for individual spaces – i. e. attitudes about whether a space should be used above all as purely a traffic environment or as a residential environment, or, a combination of both. A differentiation of pedestrian spaces into main, secondary and minor paths, and finally accesses surrounded by dwellings with their entrances all opening onto a courtyard, often implies the creation of maximum quietness and secludedness for the inhabitants, as well as the creation of the kind of spatial conditions which are sometimes supposed to promote spontaneous social grouping. But a pursuit of this arrangement at the same time tends also to result in a complete elimination of casual encounter between people living along individual pedestrian paths and those passing by these paths. On the other hand, a pedestrian network everywhere undifferentiated in relation to the location of dwelling entrances and the entrances of service facilities, usually would mean more frequent encounters between people living around a space and people moving through that space, thereby creating a mixed,





Figures 7 a & b. Caixiancun neighbourhood: (a) site plan, with street entries indicated; (b) axial map, with integration core indicated in heavy black lines.



Figures 8 a & b. Brickebacken neighbourhood: (a) site plan, with dwelling entrances indicated; (b) axial map, with integration core indicated in heavy black lines.

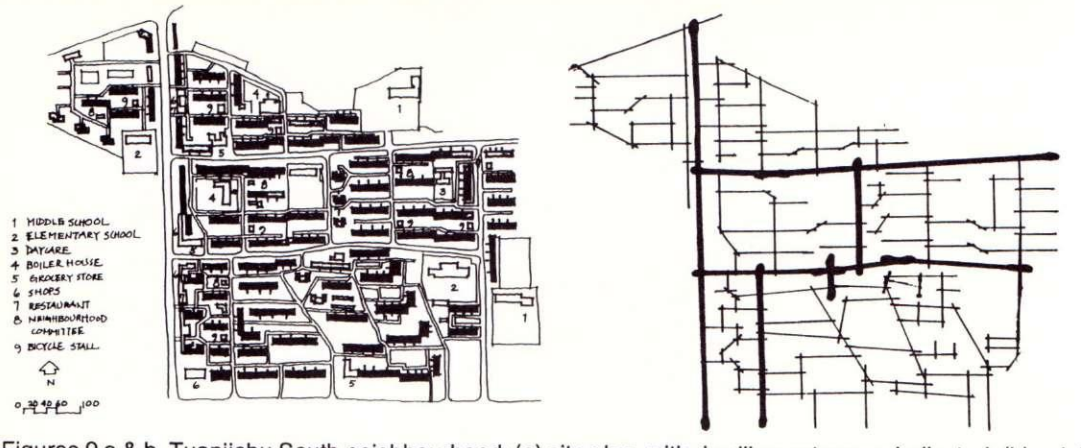
hence also potentially richer use of street spaces. But an arrangement like this often also implies the sacrifice of the kind of privacy and seclusion needed in urban residential life. The arrangement of building entrances in relation to the pedestrian spaces of a housing area, therefore, tends to have different implications for patterns of street life, depending on the kinds of layout solutions adopted.

Now, suppose that the positioning of building entrances in relation to pedestrian spaces is one of the basic issues to be decided at the early stage of a housing development; but thinking in terms of narrow functional differentiation in such circumstance tends to simplify the design rather than making both spatial pattern and use richer. What other strategies are there from which a design can make a choice when tackling this issue?

If the aim of a development is to pursue as complete a functional differentiation as possible in its pedestrian system, then one obvious choice here seems to be the removal of all the dwelling entrances from its global structure, thereby making axial spaces constituting that structure purely a traffic environment – a kind of "highway environment". The plan layout of Brickebacken neighbourhood from our sample, judged by this criterion, seems to have provided a near perfect example showing how such a morphological pattern can be obtained. As it is shown in Figures 8 a & b, despite its grid-like pattern, the integration core of the neighbourhood is clearly deprived of any dwelling entrances. Any casual encounter between people moving on the core spaces and people staying in front of their homes, seems to have been definitely eliminated from the neighbourhood.

On the other hand, if the aim of a new development is to give its global structure to pedestrian spaces used basically as a traffic environment, but occasionally also introduce some other uses into these spaces, then the spatial alternative suitable for this purpose should be one which will only let shops and some of the service facilities be located on the global structure of the development, meanwhile lets the majority of dwellings turn their entrances onto more segregated spaces or spaces which are unlikely used as short-cuts. This alternative in fact is the most common solution we can find in housing areas organized as neighbourhoods. Figures 9 a & b give an example (Tuanjiehu South) illustrating the major features of this alternative.

Finally, if one of the major aims of a new development is to attain some degree of functional differentiation in pedestrian spaces and



Figures 9 a & b. Tuanjiehu South neighbourhood: (a) site plan, with dwelling entrances indicated; (b) axial map, with integration core indicated in heavy black lines.

at the same time allow its global structure to be experienced both as traffic and residential environments, then the morphological structure appropriate for realizing this intention, should be one which allows most of the strong integration and choice spaces to be defined by dwelling entrances, thereby creating in these spaces a richer, but otherwise also subtler encounter potential. Figures 10 a & b are two illustrations showing the relationship between building entrance location and spatial structure in Skintebo neighbourhood, which is considered as well exemplifying this morphological choice. Although both the integration and the choice cores of the neighbourhood displayed a somewhat biased pattern of distribution, almost all the spaces constituting these cores are either defined by the dwelling entrances or by that of the service facilities. In addition to facilitating encounter among people coming and going within the neighbourhood, the global structure of the neighbourhood thus at once also facilitates encounter between people staying or residing on spaces constituting that structure, and those whole are merely passing through these spaces.

Discussion

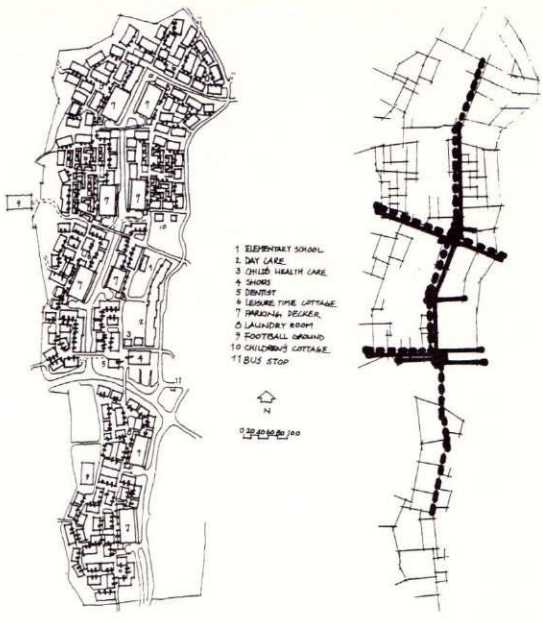
At the beginning of this paper, it was said that housing layouts designed as the neighbourhood unit are often believed to have social implications. Yet, no matter whether this belief is a true one or not, how the overall spatial patterns of complex neighbourhood layouts per se can be systematically described and compared so as to tell fundamental strategic difference or similarity between one design and another, is nevertheless a difficult question which could not always be answered by invoking the kind of knowledge we already possess.

Now, if what has been reported by and large is true – that underlying manifested similarities and differences, there are morphological properties which are characteristic of the planned neighbourhoods, and that these properties seem to be also having describable relation to pedestrian movements, to encounter – then the obvious question arising from this is: has a revelation of such things provided some plausible answer to our question? I suggest it has, and would also propose that the encounter-modulating effect of the spatial morphology of neighbourhoods may be now recognized as one relevant property for understanding strategic difference and similarity between layout patterns. This effect, as it appears, is not something implied by some programmatic functions which we can normally define and pursue according to a few known factors and principles, but something arising primarily from the spatial pattern, or morphology of a neighbourhood per se and is solely involved with generating some patterns of probabilistic encounters.

One question, however, immediately arises from such a claim. Since to say that the movement-modulating effect of neighbourhood layouts is not something "pre-programmed" by design but something arising from a built pattern at first makes one feel perplexed. We all know that buildings and urban plans are essentially artifacts, not some natural objects, and that if they are to have some functions then these functions must be "given" by man. But this conception of buildings and urban layouts, I suggest, may not fully explain the nature of these artificial things. For if we accept that both the spatial formation of complex urban layouts, and the way in which such layouts act upon our use of urban pedestrian spaces, are things which are subject to the "morphological laws" of the urban object, then the seeming paradox in the above statement may eventually disappear (Hillier, 1985; 1989).

Once it is understood that the spatial dimension of the neighbourhoods has an encounter-modulating effect, and that this spatial effect of housing layouts can be made explicit by analysis, the next question one naturally asks is how can this knowledge be of some use to design. The formulation of some strategic choices possibly relevant to future housing design – with the aim to provide the pedestrian space users of a local area with the biggest possibility to *see* people while not being committed to interact, is my attempt to provide some answer to this question.

As the strategic choices I proposed at once both state a range of design problems as well as design aims and prescribe morphological principles for tackling these problems, it seems that they should be given a proper name which will explain as well as define the exact character of these abstract and yet spatially tangible things. The expression of *intermediate formal repertoire* proposed by John Peponis (Peponis, 1990), then, appears to have provided a pertinent concept for generalizing the dual-nature of these design ideas. Strategic choices, we may say, are formal (spatial) solutions stated as morphological principles which can be manipulated not only to solve specific design problems, but also to help formulate design problems as well as design aims themselves.



Figures 10 a & b. Skintebo neighbourhood: (a) site plan, with dwelling entrances indicated; (b) axial map, with integration and choice cores indicated in heavy black respective dotted lines.

I do not claim that spatial analysis is the only way to study housing layouts if the aim is to get a better understanding of the spatial form of a housing area and its possible relevance to residential life. Nor do I believe that the few strategic choices I explored in this paper have exhausted the range of possibilities for designing layouts which may prove to be socially beneficial. I do claim however that a morphological study of the built neighbourhoods at least in part has improved our knowledge of the spatial dimension of complex layouts and its social implication. And, it is hoped, the kind of strategic design alternatives I formulated basing on such a knowledge, will ultimately also prove to be of use to the practice of architecture.

Notes

1. Though Case *j* is placed in two different columns in respective tables according to the intervals of coefficient values it actually falls in, the integration and the choice values of the neighbourhood are in effect associated with encounter rates in roughly similar strength.
2. Besides making intuitive analysis and comparison, a more rigourous study was also made in one of our sample neighbourhoods (Skintebo) to explore as to how far the spatial structure of neighbourhoods in itself will affect the density and distribution of pedestrian movement, over and above the influence of shops and other attractions. The result of the study, however showed that the extent to which density of movement co-varied with spatial properties is by and large indifferent to factors such as the operating status of shops and major communal facilities (Ye, 1993).

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