1 The City as One Thing

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Abstract

This paper summarises the latest theories in the field of space syntax. It opens with a discussion of the relationship between the form of urban grids and the process of how cities are formed by human activity; this is done by a comprehensive review of space syntax theory from its starting point in the 1970s. The paper goes on to present research into how cities balance the micro-economic factors which shape the spatial structure of cities with the cultural factors that shape the underlying form of residential areas. It goes on to discuss the relationship between activity and space and how this relationship is formed by the way different activities make different demands on movement and co-presence. The paper ends with a discussion regarding the manner in which patterns of spatial integration influence the location of different classes and social groups in the city and contribute to the pathology of housing estates. The paper concludes that spatial form needs to be understood as a contributing factor in forming the patterns of integration and segregation in cities.

Is The City One Thing Or Two?

On the face of it, the city is two things: a large collection of buildings linked by space, and a complex system of human activity linked by interaction. We can call them the physical city and the social city. Urban practice and theory must connect one to the other. But the reflective disciplines which support and nourish both - roughly the morphological disciplines on one side and the social sciences on the other - in their nature take an asymmetric view, foregrounding one city and backgrounding the other, in effect seeing the 'other' city *through* the foregrounded one, and so at best as a shadowy set of patterns and forces. It is no surprise then that, at the start of the twenty first century, we have many partial theories *about* the city, but no theory *of* the city as both of the things that it seems to be.

But is the city in any case two things or one? It will be one to the degree that the physical and social cities act conjointly to produce significant outcomes. There are good reasons why in principle we might expect it to be one thing. The social city is *either side* of the physical city: it brings it into existence, and then acts within the constraints it imposes. It seems unlikely that either is a wholly contingent process. But both relations raise uncomfortable issues of *determinism*: how can a *physical* process in the material world relate to a *social* process in a non-trivial yet systematic way. This places philosophical as well as methodological obstacles in the path of reflection and research.

In practice, we also find that any time, intervention in the city is governed by a consensus of beliefs and practices about the city as one thing: that small scale inward looking residential developments promote community, for example, or that mixed use reduces crime, or that lower densities lessens the danger of social malaise. But these beliefs shift over time, often dramatically, and it is hard to think of a case where a one thing proposition has acquired the status of a tested – or even testable – scientific proposition. The beliefs and practices allow us to act as though the city were known to be one thing, because this provides a rationale for our interventions, but all our formations and paradigms make the tacit assumption that the cities can safely be treated as two.

Paradoxically, the real challenge to our two city paradigms comes not from the well-formed, well-functioning city, but from its - real or apparent - pathology. Where cities seem to go wrong, often as a result of belief-based interventions which come in time to appear mistaken, the problem of one city confronts us with immediacy and urgency by demanding to know if there is any sense in which the physical and spatial form of our interventions has contributed to their apparent failure. The challenge was posed in the second half of the twentieth century by the precipitate decline of many ambitious social housing schemes, and the widespread public belief that the physical and spatial form of these experiments was somehow involved. Today it is posed in a more general form as the problem of the social segregation in the city, its nature, its causes and its consequences. We can easily formulate ideas about segregation purely in terms of social and economic factors without invoking space. But segregation is a spatial term and the way in which patterns of segregation and exclusion cluster in the city leads us back to the one city question: does urban segregation

have a significant physical meaning over and above its social meaning? Can segregation be, or become, a *one city* phenomenon?

The idea of space syntax

Space syntax was conceived in the nineteen seventies as an attempt to address this kind of *one city* question. Its genesis was in the remarkable architectural changes which began to appear in cities like London in the nineteen sixties, and the increasing sense which they engendered of a contradiction between – as seemed at the time - their striking architecture and the discomfiting and un-urban nature of their spaces. Space syntax began from the observation that space is the common ground of the physical and social cities. The physical city is a complex pattern of space, while all social activity and interaction happens in space. In itself, of course, this leads to an impasse. All social activity leaves spatial traces in the form of recursive patterns, but how can these relate to a physical and spatial context whose essential patterns were in all likelihood laid down long ago, under the influence of quite different social circumstances? On reflection, the radically different rate of change of the physical and social cities seems *in itself* to forbid anything but a contingent relation between the two.

But space syntax added to the existing panoply of spatial concepts a new one that potentially reshapes research questions: spatial *configuration*. The hope was that by learning to describe and analyse different kinds of spatial configuration, or pattern, in the city – for example the differences between the new social housing and traditional urban areas, which seemed *prima facie* to be critically different – it would be possible to detect any influence there might be of social factors in the construction of the these spatial patterns and also to explore any consequences there might be in terms of how social life could and did take place. By learning to control the spatial variable at the level of the complex patterns of space that make up the city, we might begin to gain insight into both the social antecedents and consequences of spatial form, and so detect signs of the social city *either side* of the physical city.

In syntax terms, spatial *configuration* means relations between spaces which take into account other relations, and so in effect relations between all the various spaces of a system. Space syntax, in effect, takes certain common measures of relationality in graphs, and first theorises them in terms of their potential to embody or transmit social ideas, and then turns them into measures and representations of spatial structure by linking them to geometric representations of the system of spaces under examination (Hillier and Hanson 1984). These measures are essentially formal interpretations of the notion of spatial integration and segregation, and it was the formalisation of these terms which first seemed to identify structures which linked the social and the spatial. Providing a measurable scale from *segregation* to *integration*, enabled statistical comparison of different spatial forms across cultures, and so provide a platform from which social origins and consequences might be investigated.

This was an unfamiliar idea. It was, in effect, being suggested that space has its own formal logic prior to acquiring a social logic, and indeed that it was this logic of space that was exploited in order to render space *social*. This is the core argument of 'The Social Logic of Space'. The autonomous potential of space to form patterns was, in effect, seen as the means through which it is able to give expression to social meanings. This challenged paradigms on both side of the two city divide. But it also suggested that there could be a one city approach to urban research which was both quantitative and informed by the search for social and cultural influences and meanings.

From these beginnings, space syntax has evolved into a set of tools linked to a set of theories, the two together giving rise to a set of interpretative models for different socio-spatial phenomena. Interpretative models are schemes of analysis which work for particular phenomena. For example, we have an urban movement model, a land use model, a crime model, even a social segregation model, and most important of all a general urban model in which the integration-segregation dimension is shown to be a primary spatial dimension on which cities are organised. These models are quite unlike the more familiar engineering models, since they seek to be *explanatory in themselves* of the phenomena they address. They show that by clarifying space in a particular way the social origins and consequences of the spatial patterns can be brought into clear view. It is because they seek to be explanatory in themselves that syntax models have proved to be so applicable in design.

In what follows we first explain the foundations of space syntax, and go on to give an overview of the range of techniques that are now available, and what questions can be addressed with them. We then outline the general theory of the city to which this has given rise, which shows why the issue of integration-segregation

is close to the heart of what cities are when considered as one thing. We then outline a series of characteristic research problems that have been addressed with space syntax, and the kinds of models we have developed to try to solve them. We follow this with sketches of a few of the hundreds of projects on which space syntax has been applied in recent years, and introduce the other parts of this special issue.

Foundations

Space syntax is built on two formal ideas which try to reflect both the objectivity of space and our intuitive engagement with it. The first is that we should think of space not as the background to human activity, as we think of it as the background to objects, but as an *intrinsic* aspect of everything human beings do (Figure 1.1) in the sense that moving through space, interacting with other people in space, or even just seeing ambient space from a point in it, all have a natural and necessary spatial geometry: movement is essentially linear, interaction requires a *convex* space in which all points can see all others, and from any point in space we see a variably shaped, often spiky, visual field we call an *isovist* (Benedikt 1979).

Each of these geometric ideas describes some aspect of how we use or experience space, and this makes it useful to try to see how buildings and cities are organized in terms of these geometric ideas. For example, it seems to matter that space in cities is for the most part linear – streets, boulevards, avenues, alleys and so on are all linear concepts - with occasional convex elements we call squares or public open spaces, each the centre of a variable isovist. In fact, urban space has all three properties, and by being clear about this geometry we can begin to see why urban space is the way it is.

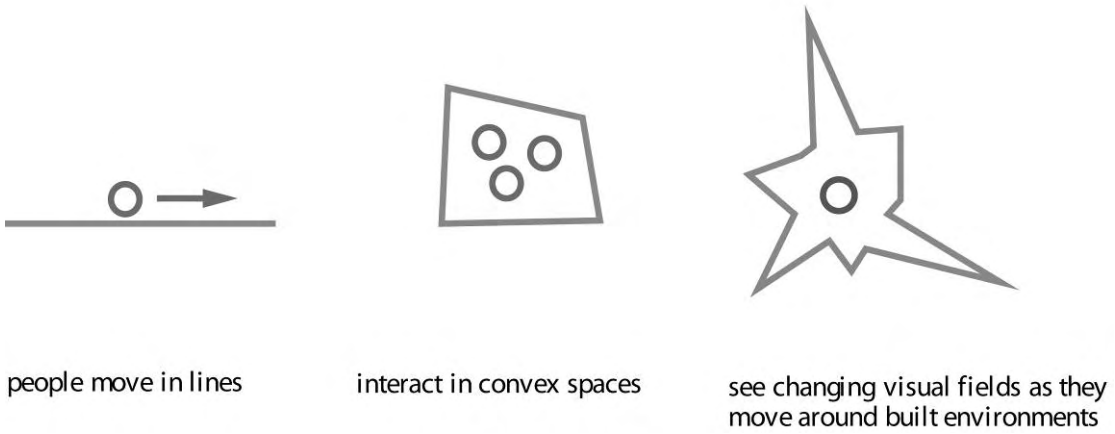

Figure 1.1 Space is not a background to activity, but an *intrinsic* aspect of it

The second idea is that human space is not just about the properties of individual spaces, but about the inter-relations between the many spaces that make up the spatial layout of a building or a city. This is what we formally call the *configuration* of space, meaning the *simultaneously existing* relations amongst the parts which make up the whole. It is notable that language has terms for spatial configurations, but insofar as these are precise, they describe at most relations between three entities. English prepositions such as between, beyond or inside all fall into this category. For more complex patterns of space, the undoubted competence that people have in understanding them seems to be, like the structure of language, at the unconscious level of ideas we think *with* rather than *of*, since we do not have precise terms for more complex patterns of space.

The reason configuration matters is that it is able to express the property of space that, more than any other, is the means by which space both acquires social meaning and has social consequences: that a spatial configuration not only looks but *is* different when seen from different points of view in the layout. We can make this visually clear by taking the layout in Figure 1.2, and drawing *justified graphs* (in which each circle is a room and each linking line a door, and the graph is aligned upwards in layers from each space in turn) from spaces 5 (left) and 10 (right) to show what the pattern of space looks like from each. The two graphs look quite different, in that one is shallow and the other deep, but are of course the same graph looked at from different points of view. But although different, each graph gives a true picture of what the layout looks like from that space, and so expresses a real property of the layout.

The shape of the justified graph, or *j-graph*, then leads us to our measure of integration-segregation. The shape of each graph shows the degree to which we must pass through other spaces to go from a particular space to all others. This will be high or low according to whether we have a shallow graph, as on the left, or a deep graph, as on the right. To the degree that the graph from a space is *shallow* we say it is *integrated*, and to the degree that it is *deep*, *segregated*. So we can index each space in the layout in terms of the degree to which it integrates the complex, and the average for the whole will be the degree of integration or segregation of the whole complex[1].

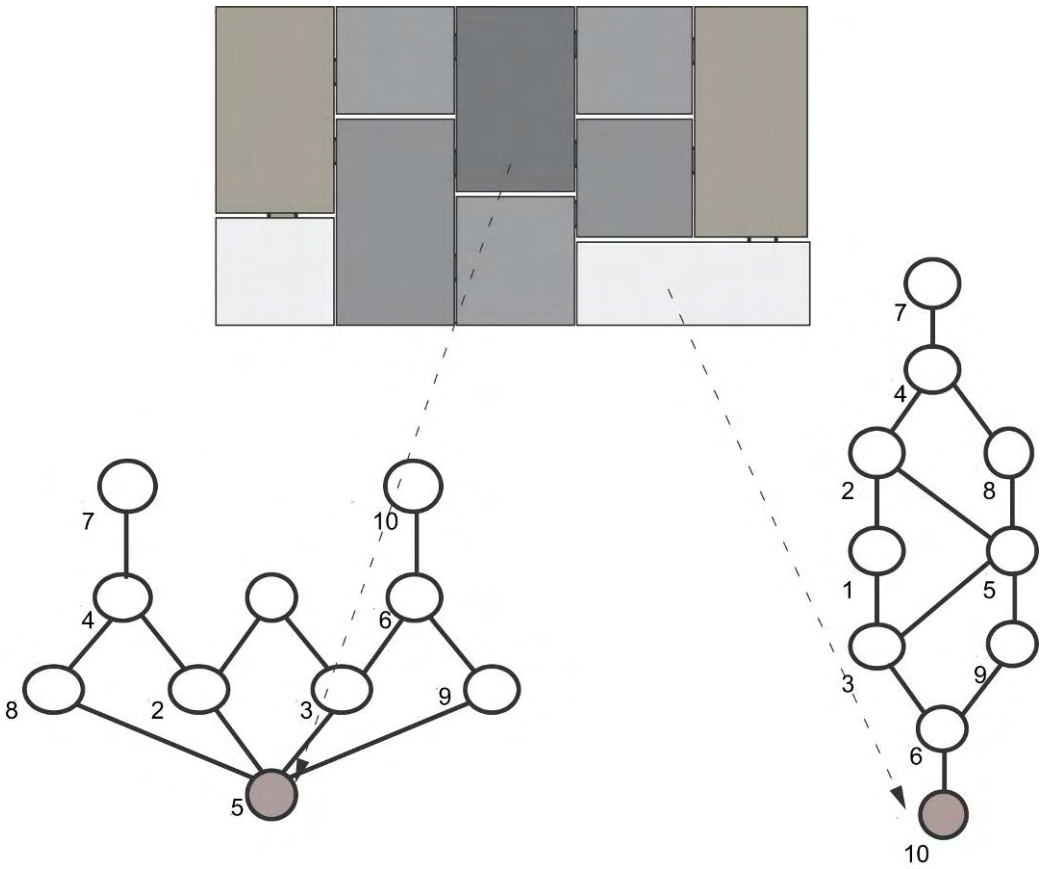

Figure 1.2 A spatial layout both looks and is different when seen from different spaces within it

Space syntax is about applying configurational measures to the patterns of different geometric elements that are created by buildings and cities. Whether we choose lines, convex spaces, isovists, or even points as the elements for our analysis depends in what aspect of functionality we are investigating, that is, what aspect of human spatiality we are investigating.

Making buildings speak

By looking at space in this way, we can begin to see both how social and cultural patterns are imprinted in spatial layouts, and how spatial layouts affect functioning. For example, at the simplest level, we can show how cultural differences are expressed through the layout of rooms in domestic space. If we take the French farm house in Figure 1.3, we find the *salle commune* (the space of everyday living and reception of informal visitors) is the most integrated internal space and the *grande salle* for formal reception the one of the most segregated, along with the *bureau* of the male owner. We can show such patterns visually by using colours to index numerical values, always using darker greyscale for the most integrated through to light greyscale for least. ‘Colouring-up’ is a vital aspect of space syntax research, since it allows us to search for patterns visually, and therefore intuitively, as well as using simple mathematics. We also find that the salle commune lies on all rings of circulation, so that if you remove it, the layout becomes virtually a single sequence of spaces. This is not always the case in French houses with 'salles communes'. Sometime a transition space - say a hallway or corridor - is the most integrated space, and where this is so, the salle commune loses is dominant spatial role. Our studies suggest that this may be to do with gender roles, since the integrated salle commune is a space dominated by female activity (Hillier, Hanson & Graham 1987).

This is one example of the ways in which spatial configuration is shaped by culture. In general, to the degree that integration values for different activities in the house are in the same or a different order, we can see evidence of cultural commonalities or differences across a sample. What we are seeing is the constructive effect of society and culture on spatial patterning; by giving function a configurational meaning in the layout, in addition to expression through equipment, furnishing and decorative style.

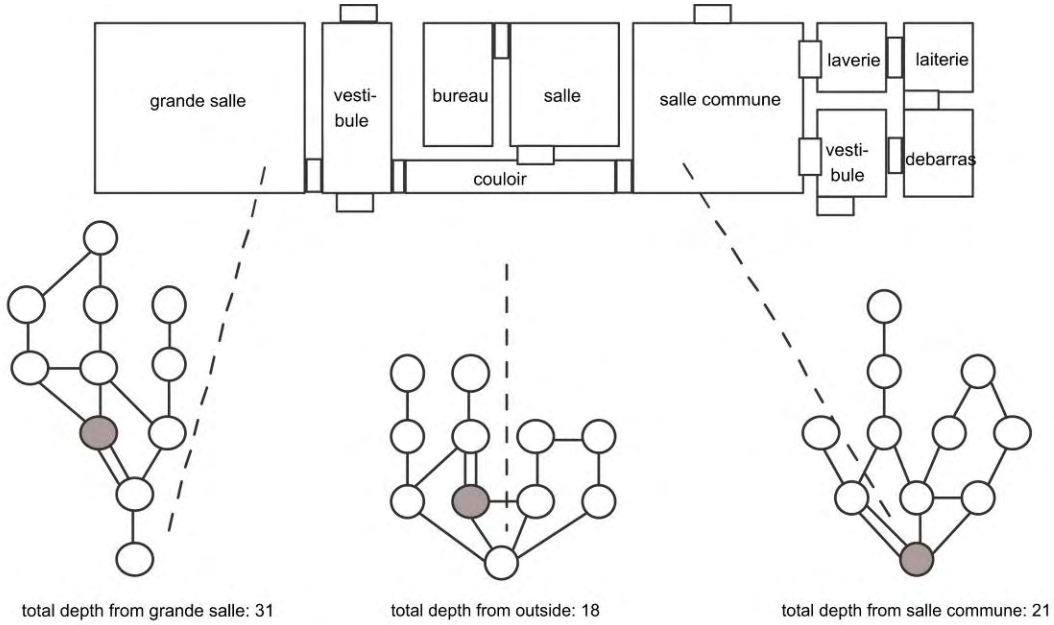

Figure 1.3 The layout of a house looks more or less integrated from different points of view

We can also use space syntax to investigate the *effect* of spatial layout on functioning. In Figure 4, we show on the left traces of 100 people entering the Tate Britain gallery in London and moving about for ten minutes. On the right is a more complex version of the analysis we saw with the house, a *visual integration* analysis of all the visual fields from every point in the Tate plan. Technically, it draws the visual field from the centre of each square of an arbitrarily fine tessellation filling the plan, overlaps these so that an overlap counts as a connection, and calculates how many visual fields you need to use to get to see the whole gallery from any point within it. Again, the darkest locations are the most visually integrated, through to lightest for the least. It is easy to see that the movement and space patterns resemble each other as patterns quite closely.

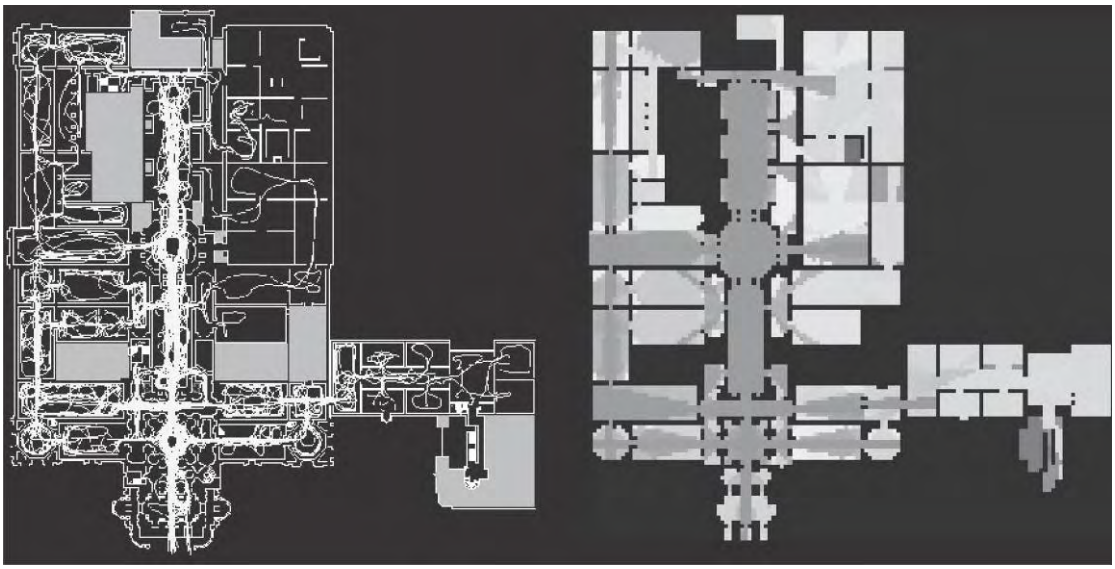

Figure 1.4 First ten minute movement traces (left) and *visual integration* analysis (right) of Tate Britain

We can check this statistically. By correlating the *visual integration* values with observed movement, it turns out that about 68% of the differences in movement rates in rooms can be accounted for by the visual field structure, implying that people are using the space structure of the Gallery, rather than, say, the attractive powers of particular exhibits, to guide them around the gallery (Hillier et al. 1996).

This then is how space syntax works. By analysing space rigorously, and observing human activity carefully, we can show that space and social activity relate in two ways: a spatial layout can reflect and embody a social pattern, as in the case of the French house, where space was laid out and categorised to give reality to a culturally given pattern of activity, and so reinforce and reproduce it; and space can also shape a potentially social pattern, as in the case of the movement study, since by shaping movement, space also creates a pattern of natural co-presence in space.

Another way of saying this is that space can be used both in a *conservative* mode to structure and reproduce existing social relations and statuses, usually by using space to segregate, and in a *generative* mode to create the potential for new relations by using space to create co-presence through integration. As we will see, the conservative mode leaves things much as they are, while the generative mode, by creating a richer field of potential encounter, can lead to the appearance of new social connections.

The basic urban relation

The distinction between the two modes of generating space on the integration-segregation dimension is critical to understanding how the social city is *either side* of the physical city, that is, how the space of the city comes to embody social ideas in its layout, and how the layout has consequences for the ways in which collections of building come to life - or fail to thrive - as living cities. First we must understand a relation we glimpsed in the Tate example, and which we have come to see as the basic urban relation: that the configuration of the urban street network, which is the largest spatial pattern in the city, is *in and of itself* a key determinant of movement flows and so co-presence in space. This may not sound very significant, but it has huge consequences for both the form and functioning of cities. We call it the theory of *natural movement* (Hillier et al. 1993). To some this will be an unexpected idea and smack of long discredited determinism. We will argue that it is nothing of the kind, and that, on the contrary, it is – with a little reflection - intuitively clear, mathematically necessary and empirically demonstrable. It is also the key to understanding cities as socially meaningful patterns of relative integration and segregation.

First, let us look at the idea intuitively. Consider the notional grid in Figure 1.5a with a main street, cross street, side streets and backstreets. Imagine that the streets are lined with houses, and people move between the houses by the more or less direct routes:

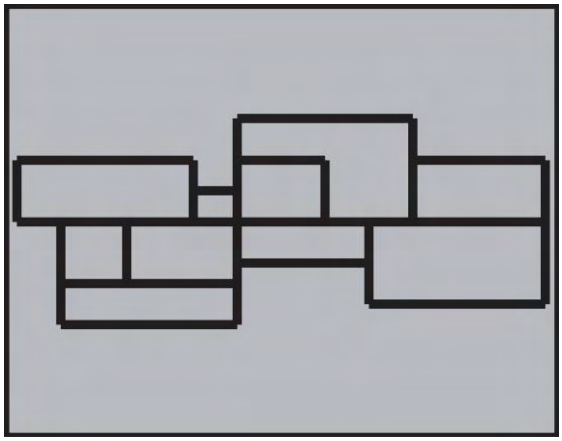

Figure 1.5a A notional grid with a horizontal main street, vertical cross street, side streets and back street

It is clear that more people will pass *through* the main street than the side streets or back streets, and more people will pass through the central sections of the main street than the peripheral ones. The main street is easier *to* get to than other streets - it is more accessible. The cross street also seems to have good potentials for both *to* and *through* movement, but we would guess it to be less than the main street. What is clear is that we intuitively expect the position of each street in the overall grid to affect emergent *to*- and *through*-

movement flows in streets and their different parts. It is not a matter of psychology, but the way the grid is put together.

Now to- and through- movement are the two principal components of human movement. For every trip, we select a destination to go to, and a series of spaces to pass through on the way. Both obviously matter to how cities work. For example, over time we are likely to go to more near than far destinations, so if some locations are in some sense 'nearer' too all locations within a certain radius than others, as in Figure 1.5a, this will give these locations greater potential as destinations than others simply by virtue of have easier accessibility. If we want to open a shop, for example, it would make more sense to put it in an accessible rather than inaccessible location. Similarly, if routes between all pairs of spaces in a layout pass through some spaces more than others, as is clearly the case, it will likewise be sensible to locate the shop in one of those spaces, though it may not always be intuitively obvious which these spaces are. The point is that these potentials are commonsense and even familiar properties of spatial layouts.

Both of these potentials can be measured. The measure of accessibility for to-movement of a space is our integration measure. The measure of through-movement potential assesses the degree to which each space lies on simplest or shortest paths between all pairs of spaces in the system. In syntax this is called the choice measure[2]. Figures 1.5b and 1.5c show the integration and choices measures applied to the axial map, and coloured up in shades of grey from dark for integrated, to light for segregated. Syntax also applies both measures at different radii, that is, it calculates integration with respect to the system up to a certain distance away, and choice for trips up to a certain length. This allows us to apply both measures on a continuum from local to global, yielding a powerful matrix of measures to investigate structural features of urban space in terms of its basic movement potentials.

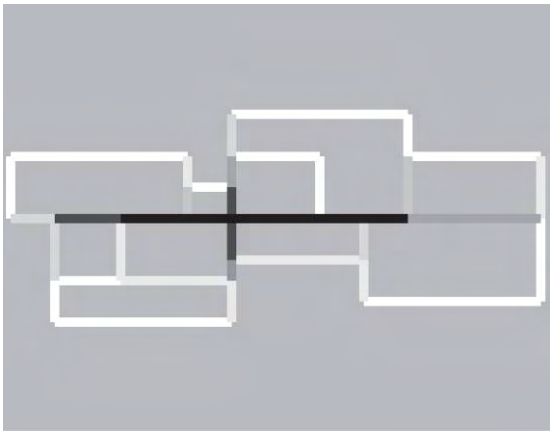

Figure 1.5b Notional grid: pattern of 'integration' values - or the closeness of each line to all others - from dark for highest through to light for least

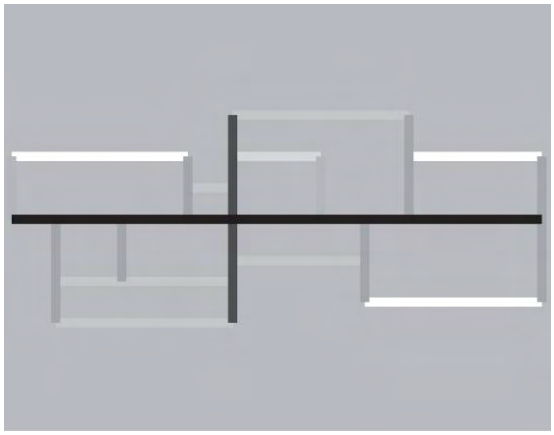

Figure 1.5c Notional grid: pattern of 'choice' values, or the degree to which each line lies on simplest paths from each line to all others, from dark for highest through to light for least

But what should we apply these measures to? Urban space is after all continuous and more often than not offers no obvious or natural division into units. The syntax approach to this question was first to take the predominantly linear nature of urban space seriously, and propose a representation of the street network based on the longest and fewest lines that could be drawn through the system (Hillier and Hanson 1984)[3]. We then treated the lines as the elements of a graph, with the junctions as links[4], and we could then calculate the measures of integration and choice at variable radii as we wanted. The decision to make the lines into elements, had the effect of internalising the line structure into the graph, and so in effect capturing key features of the geometry of the street network in the graph.

These *least line* axial maps turned out to have some remarkable properties. First they turned out to have a fractal nature (Carvalho and Penn 2004), in that all urban street networks, from Shiraz to Chicago, at whatever urban scale we consider them, are made up of a very small number of long lines and a very large number of small lines. Second by simply applying the *integration* and *choice* measures to the least line map and correlating the spatial values with observed movement rates, we commonly found that somewhere between 60% and 80% of the differences in movement flows along lines could be accounted for in terms of the configuration of the grid itself (see Hillier 1989, Hillier and Penn 1996 and etc.)

There was a second problem. In making our calculations on the basis of the axial map, we are in effect calculating distance as the number of times we have to turn (that is, to move from one line to another) go from one line to another. Is this how human beings do it? It is commonly assumed that people, insofar as they make spatial (as opposed to temporal) judgments in selecting routes, will simply minimize distance. But there is increasing evidence that our notions of distance are severely compromised by geometrical and topological factors, and even by the direction in which the estimate is made[5]. To solve this problem, and also to make the analysis more precise, a far more powerful and disaggregated version of the line analysis technique has been developed (Hillier and Iida 2005). Starting from the least line axial map, we divide each line into its segments (between intersections) and represent the segments as the nodes of the graph with the intersections as links. We then assign integration and choice measures using different definitions of distance: *shortest path (metric), least angle change (geometric), fewest turns* (*topological)* weightings to relations between each segment and all others, and we apply them at different *radii* from each segment, also defining radii for shortest, least angle change, and fewest turns paths. This yields a matrix of measures which we can use to see explore how people actually move in cities (Figure 1.6) (Hillier and Iida: 479).

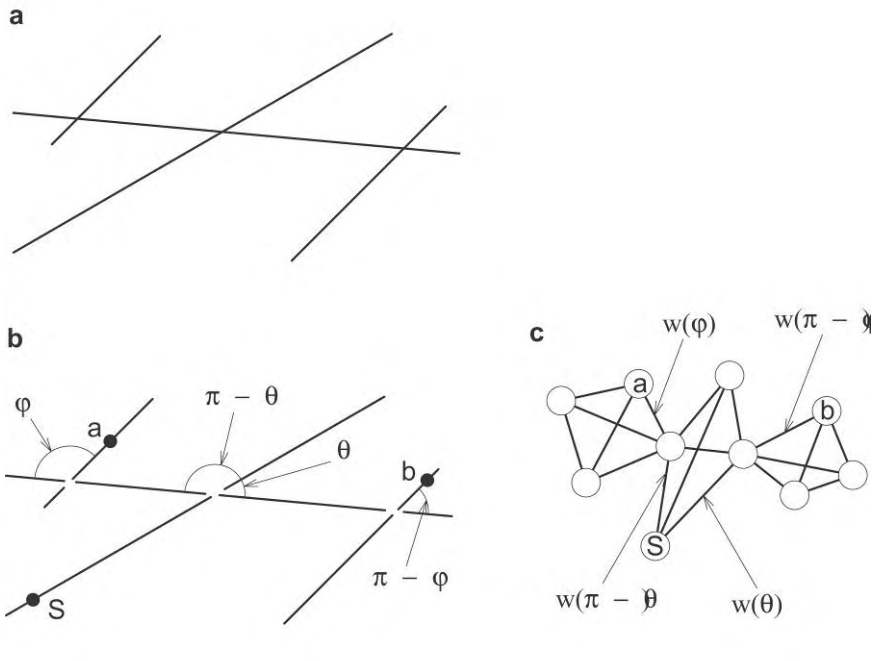

Figure 1.6 From the line model to the segment model

With these techniques, we can make different mathematical analyses of the same urban grid, and then ask which analysis agrees best with the observed pattern of movement. In a recent study of four different urban areas of London, the answer was unambiguous: *least angle* analysis is the best predictor of movement, followed closely by *fewest turns*, and with *metric shortest path analysis* well back in third place. The only plausible interpretation of this result that people do not navigate with a mental model of metric distances, but with a geometric and angular model of how the alignments of the grid are connected to each other. As cognitive scientists have long suspected, but been unable to show conclusively, we navigate with an architectural model in our heads, not a simple account of metric distances. This has major implications for how we design cities.

The bringing to light of the relation between grid structure and movement also opens up the possibility of a new way of modelling cities. Historically, mathematical approaches to modelling cities have been Newtonian. The city is conceptualised as a set of discrete zones represented as points. Exchange between zones is proportional to their combined masses inverse to some definition of distance (Wilson 2000). We can call this the *attractor* theory of cities. There are of course familiar problems with such models. They are coarse grained and neglect micro-structure, and it is not clear how there can be a theory of macro-structure without a theory of micro-structure. Zones are arbitrary constructs and do not exist in any physical sense, which makes it hard to relate reality and model in a morphologically useful way.

But if it is the case, as we believe has now been amply shown, that the fundamental determinant of movement is the configuration of the street network itself, a factor given scant attention in attraction models, then it seems that these models are not theoretically optimal either – especially if, as we will show, the pattern of attraction is itself powerfully shaped by the grid induced movement pattern and so should not be treated as primary in a model.

The structure of the urban grid

Let us then use the syntax technique to investigate the structure-function relation in cities, starting with the structure of the urban street network itself. First we can use the analysis to show how cities tend to acquire a certain generic large scale structure. For example, if we take Apt, a small town in France (Figure 1.7a) and analyse its integration pattern using the segment least angle analysis[6] (colouring up from dark grey to light grey, Figure 1.7b) as before, we find the darker lines form a striking pattern: a kind of *deformed wheel*: there is a 'hub'of integrated lines at or near the centre, integrated 'spokes' which link centre to edge, and sometime also we find integrated 'rims' or edge lines. The wheel forms the dominant pattern of public space, where most of the shops are, while the lighter areas in the interstices are predominantly residential, though of course with gradations between the two. So this means that the structure is not purely formal matter. It has to do with what is going on in the social and economic life of the town. As with the house, the analysis has detected a certain *social logic* in the plan.

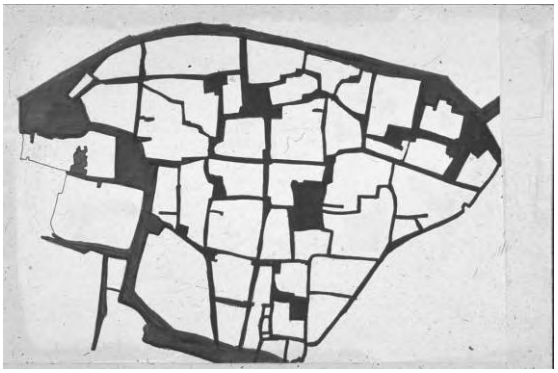

Figure 1.7a The plan of Apt, a small town in the South of France

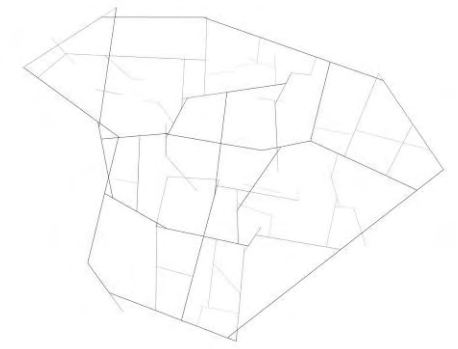

Figure 1.7b The integration map of Apt, a small town in the South of France

While not universal, the deformed wheel pattern is found again and again in the large scale structure of cities. Figure 1.8 shows it in the central areas of Atlanta.

Figure 1.8 The street plan of the central areas of Atlanta showing the deformed wheel

More remarkably, Figure 1.9 shows it in a more complex form with multiple rims in the metropolitan area of Tokyo, a very much larger system

Figure 1.9 The deformed wheel pattern in the metropolitan area of Tokyo

We find it the same underlying pattern in Venice, even without the canals, and in London we find it approximated at two levels: that of the metropolitan area as a whole, and at the level of the local area, as in Figure 1.10.

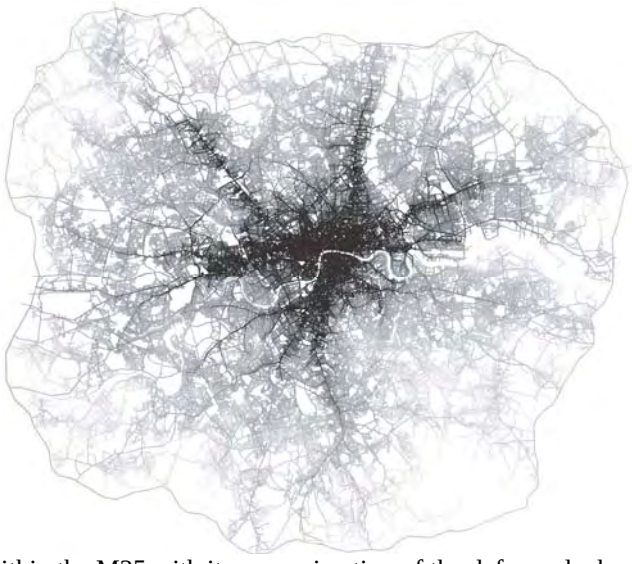

Figure 1.10 London within the M25 with its approximation of the deformed wheel

This may be why people think of London as a set of urban villages. Its ‘villages’ are usually the hubs of local deformed wheels, with the spokes acting as strong linkages to the larger scale grid, so providing locally the strong centre-to-edge links that the large scale deformed wheel provides for the city as a whole.

Why the deformed wheel? The answer is simple. It is a way of overcoming the natural tendency for centres to become segregated as the city grows around them by linking centres to edges, so accessing strangers to

the heart of the system and inhabitants to the edges. So this underlying structure of the city is a spatial phenomenon, but one which is shaped by the city as a social thing.

The integration patterns we are finding, it will be recalled, measure the accessibility of street segments as destinations, and so can be thought of as recording the to-movement structure of the city. If we look at the patterns formed by the choice measure, we are looking at the through-movement patterns, and we find these, while often overlapping with the deformed wheels, are rather different and always take the form of a network. Figure 1.11 shows on the left the structure of metropolitan Tokyo and on the right that of London revealed by the measure of choice:

Figure 1.11a The 'choice', or through movement structures of Tokyo

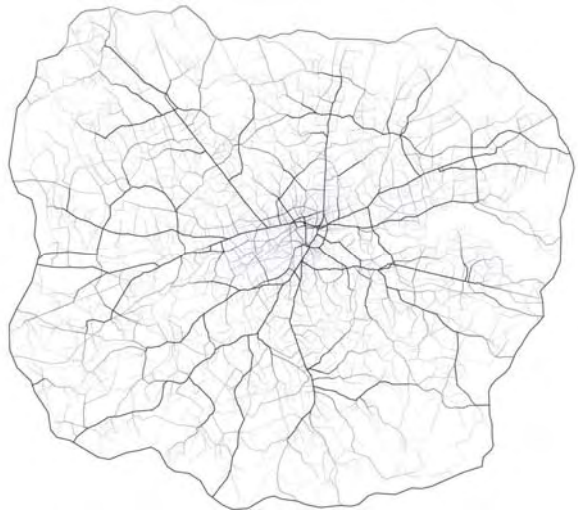

Figure 1.11b The 'choice', or through movement structures of London

The two measures can be used separately or in combination to examine the structures of different cities. Both are measures of integration-segregation, though of course in rather different senses. Most important, they can be applied at different urban scales by restricting the radius at which it is applied. For example, at the level of the whole city, choice often identifies the natural boundaries of areas (Peponis et al. 1990), but by restricting the radius, the measure often brings to light a much finer scale structure, reflecting the fact that shorter trips will tend to prioritise more local spaces. Figure 1.12 shows part of North West London analysed first (left) for trips of any length (and so for the most part for longer trips) and then (right) for trips up to 1.25 km. The right figure picks out core spaces of several 'urban villages'.

Figure 1.12a Choice analysis of part of north west London for trips of any length

Figure 1.12b Choice analysis of part of north west London for trips up to 1.25km

The dual city

But we have generated something of a puzzle. Cities are geometrically very different – a city in the Arab world for example will have little in common geometrically with a North American city – so how do they

come up with similar large scale patterns? Do cities, in spite of their differences, have certain commonalities in how they are generated? Our studies suggest that cities in general are created by a dual process, and each side of the duality exploits the relation between space and movement in a different way. On the one hand there is a public space process which is about bringing people together, and which therefore orders space in such a way as to optimise the reach of spaces and so maximise movement and co-presence. This process is largely driven my micro-economic factors, and tends to be invariant across cultures as trade and exchange always work the same way. The public space process gives rise to the global structure of the city, usually some variant on the deformed wheel.

On the other hand, there is a residential space process, which uses space to restrain and structure movement in the image of a residential culture of some kind, seeking perhaps to structure relations between inhabitants and strangers, men and women, and so on. Domestic space and its environs is usually the richest expression of culture in space, and of course it is different across regions, and even within regions. This is why we find such great differences in the fabric of the background space of the city - its geometry, its connectivity, its degree of openness - in contrast to the tendency of global structures towards universality.

So a micro-economic process generates the global similarities between cities, and a cultural process the local differences. We can illustrate this dual process with singular clarity in a city with more than one culture (now unfortunately separated): Nicosia in the island of Cyprus.

Figure 1.13a Old Nicosia within the walls

Figure 1.13b Old Nicosia integration analysis

In Figure 1.13a of Old Nicosia within the walls, top right is the Turkish quarter and bottom left the Greek quarter. Their line geometry is different. In the Turkish quarter, lines are shorter, their angles of incidence have a different range, and there is much less tendency for lines to pass through each other, and there is a much greater tendency for lines to form distinct local groups. The integration analysis (Figure 1.13b) confirms the differences. Syntactically, the Turkish area is much less integrated than the Greek area. We can also show that it is less intelligible, and has less synergy between scales (Hillier 1996), between the local and global aspects of space. Yet in spite of these strong cultural differences in the tissue of space, we still find Nicosia as a whole is held together by a clear ‘deformed wheel’ structure. The deformed wheel, as it were, overrides the cultural differences in the residential fabric of space, and creates the global system of spaces where cultures come together.

The polycentric city

We see then that society shapes the spatial form of the city by exploiting the link between grid structure and movement in different ways, on the one hand to generate interaction, on the other to restrain it in the image of a culture which is to be conserved by being built into space. The generic outcome is that all cities take the form of a network of busy and quiet zones, often in close proximity, which are essentially gradations of integration and segregation arising from our two measures. So we see the origins of the form of the city clearly in the spatialisation of society.

But what about the consequences? Are there effects back on the spatialisation of society from the spatial forms that have been created? In fact the spatial form of the city sets in motion the process by which collections of buildings become the living cities we know, with all their density and diversity of spaces and activities. It works like this. Because – at any stage of its development - the grid shapes movement flows, it means that some locations in the grid are naturally movement-rich, while others are naturally movement-poor. This effect may be found at the area level, but it will also be found at the level of this street rather than that street, and even this street segment rather than that street segment. The consequence is of course that activities and land uses that benefit from movement, such as retail, will migrate to locations which the grid has made movement rich, locally or globally, while others which prefer to avoid movement will seek out movement poor locations. In movement rich locations, the presence of movement seeking land uses will attract more movement, and set up multiplier effects which will bring more, and more diverse, land uses into that location, in proportion to the global and local properties of the grid. Where the movement-rich process becomes sufficiently intense, it will feed back on the grid to improve local inter-accessibility by reducing the scale of the grid - where the local grid does not already have that critical property (Hillier and Penn 1996).

The effect of this process is to create the city as it is: as a network of linked centres at different scales, from a couple of shops and a café to whole sub-cities (Hillier 2001) all set into a background of the residential space which continues to make up the greater part of the city. This is the fundamental form of the city – if of course it is permitted to happen. We find in effect a basic partition of the city into a dual pattern, the one created by and responding to micro-economic forces, the other, the residential part, responding to cultural forces, the one more integrated the other more segregated.

The creation of the network of centres at all scale, including the shift of centres towards edges, is the culmination of this process creating process, so we will illustrate from a place where it is not supposed to happen: the USA. Figure 1.14 shows over a century and a half how global and local factors combined, that is the intersection of two main boulevards and local grid intensification, to form this exceptional vibrant out of town centre. In general, of course, we can demonstrate these effects statistically as we did with movement, by simply correlating the scale of local centres with the spatial properties of the street network. As with movement, the relation is far from perfect, but it is pervasive.

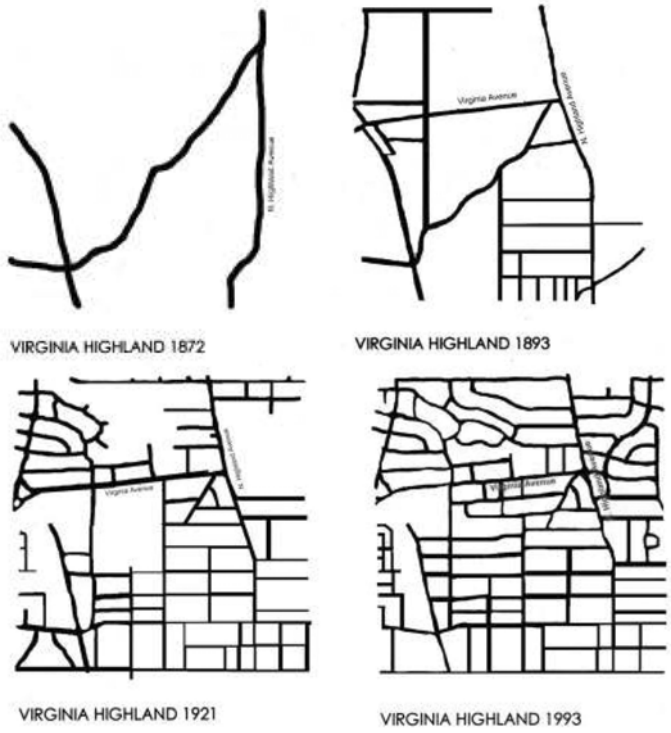

Figure 1.14 The historical evolution of a local centre, Virginia Highland in a US city, Atlanta, from 1872 to 1993, showing how global (the intersection of two main boulevards, Virginia and Highland) and local (the grid intensification around the intersection) factors combine to form the live centre. Adapted from Allen, Peponis and Conroy (2001): 7-8. Image courtesy Doug Allen

So we see that there are precise and analyzable senses in which society is *either side* of the city, both shaping its form through its spatialisation and then finding its spatialisation changed – many would say enhanced - through that form. We have shown that there is a generic relation between the city of space and the city of activity. But there is a crucial difference between this theory and what we might expect from seeing the city through the perspective of practice. In practice, a key task is to match particular activities to particular spaces, in the sense that a layout is intended to be an organization of activity. We might then expect a theory of the relations between the two cities to be in some sense a generalization of this, but it is not.

What we have shown is that the spatial form of the city arises not so much from a relation between this activity and that – though this may from time to time make its mark – but between different *kinds* of activity and the demands that they make on movement and co presence. The relation of activity to space is generic not specific: it passes through the grid configuration-movement relation. This is why we find over time that wholly new patterns of activity routinely accommodate themselves in existing cites without undue strain and with the minimum of reshaping. We may reasonably expect this to continue into the future.

Pathological Space

In interpreting cities through their spatial networks, space syntax shows that cities are constructed spatially first and foremost as patterns of gradations on the scale integration-segregation. In cities across different cultures relative segregation expresses itself primarily through local residential space. In contrast to the more global network of linked centres, which tends to maximise the integration of space, residential space expresses cultural values through its distinctive kind and degree of relative segregation.

Where then and how does spatial segregation become a social *problem*? The answer seems to be: when spatial segregation becomes extreme and loses its cultural form, as, we conjecture, happened in some of the experimental twentieth century social housing areas. When this happens, society and space are no longer interacting on the familiar terms of a spatialised culture, but in terms of a raw confrontation between new forms of space and an absent spatial culture. In investigating this, we would be moving space syntax much closer to the ground of social research. How can this be done? The key is that when seen as configuration, spatial patterns can be represented numerically, and on a space by space basis, and this allows us to give space equal status in the data table to any other variable that can be expressed numerically, including of course social and economic variables[7]. We can compare spatial and social phenomena as patterns of numbers.

A pioneering example of such a study in the 1990s, focused on a much-praised low rise high density housing estate, Maiden Lane, in Islington, London, which went from winning awards and praise from residents to being described by the police as a 'ticking time-bomb' in less than four years. Both the police and the local authority believed that the unusual experimental design had been a factor but could not say how. The space syntax research group tried through a detailed spatial and social study of the estate to formulate a precise and credible mechanism through which spatial factors might have been involved in the precipitate decline of the estate (Hillier, 1991 and revised in Hillier, 1996: 183-214).

The first thing the study showed was that the axial scale of space was dramatically reduced compared to the surrounding residential streets of Islington, London (figure 1.15). The spatial pattern was also much more complex, and there was no internal structure of the kind that is normally found in residential areas. Instead the analysis showed that the estate was structurally segregated from the surrounding streets in that its spaces were more or less uniformly segregated and had no continuity with the local area. The effect of this spatial pattern was that the estate was integrated at its edges but segregated in its interior, and this was reflected in the adult movement pattern which fell off sharply from edge to centre. The downscaling of the space and the absence of movement in the interior in fact created a situation in which even during the day you would be on your own in space for most of the time, in contrast to the surrounding residential area where the scaling and organisation of space meant that for most of the time you were co-present in space with more than one other person. In such circumstances the reports of residents of feeling fear, especially after dark, in most parts of the estate seemed to have objective correlates. Again, reasons for feeling comparatively secure in the surrounding area seemed clearly to do with the way in which space produced natural co-presence through movement.

Figure 1.15 Global integration of the Maiden Lane housing estate (in circle) within its urban context

Further striking contrasts in the 'social' nature of the space came from studying children's spatial behaviour. First, in contrast to a ten-to-one ratio of adults to children in the surrounding residential streets, the ratio on the estate was on average four children for every adult. It was clear that children were using spaces that were not being used by adults for movement. Analysis then showed that children were using the most integrated spaces that were not being used by adults, and in these spaces children formed much larger groups than on the outside. The effect was that children seemed both visually dominant on the estate, but were also removed from the kind of everyday surveillance that comes from adult movement. We showed this graphically by a useful statistical trick. Where in the surrounding area children and adults used space more or less in the same proportions, a scattergram plotting the two rates for each space would show a more or less linear relation between them: the more adults, the more children and vice versa (Figure 1.16a). Within the estate the distribution of points was L-shaped, in that the spaces prioritised by adults were not used by children and vice versa (Figure 1.16b). To a lesser degree the same was true of men and women. We called this the L-shaped problem, and showed it could be found to varying degrees in ten housing estates across London.

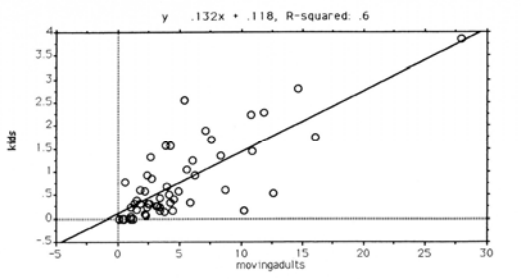

Figure 1.16a Encounter rates per axial line of moving adults to static children: surrounding street pattern

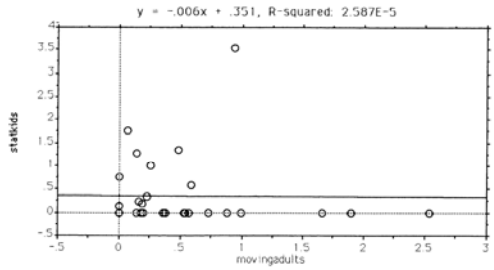

Figure 1.16b Encounter rates per axial line of moving adults to static children: housing estate

The overall effect of the spatial design of the estate was that the over-complex and structureless spatial layout of the estate had obliterated the patterns of natural movement and co-presence between different kinds of people that is the norm in urban space, and which intuition suggests is the source of our sense that urban space is secure and civilised. Unfortunately there were worse consequences in that the spaces abandoned by adults became the natural loci of vandalism and petty crime, with the effect that the estate began to appear disorderly and run down. Then as this spatial process was underway, a social variable intervened in that the local authority found it necessary to locate some problem families on the estate. How

far this was because the estate was beginning to look like a problem estate is hard to ascertain. But there is little doubt that the pathological spatial process had produced an appearance of decline and a 'bad community' perhaps before it had occurred. In this sense we might speculate that perhaps the physical symptoms had played a role in creating the disease. The key thing here is the identification of a clear spatial mechanism which can play a part in the broader social process of perceived and actual decline.

Self-Generated Settlements

Another case where a clear spatial mechanism could be shown to be involved in a social process came with a study of informal settlements in Santiago in Chile (Hillier et al. 2000 and Greene 2003). The problem was why some self-generated settlements with similar origins had consolidated into well-functioning neighbourhoods, whilst others had stagnated and others again had become centres of social pathology. By complementing space syntax measures with precise data-gathering on site (including demographic and economic data, interviews and infrastructure data as well as land use and movement data), we were able to shed light on the process of consolidation in each site. Multivariate analysis showed that the critical variable was the degree to which the layout and location of the settlement permitted the development of informal economic activity on the edges of the settlement, allowing the settlement to participate in a wider spatial economy. Those who succeeded educationally tended to leave the settlement, while those who developed successful businesses stayed on and invested in other aspects of the consolidation process. In other words, spatial integration into a more regional context of movement gave an advantage over those that were relatively segregated, and this was in fact the single most powerful variable in the consolidation process.

A third case of a spatial mechanism as part of a broader social process was found in the case of immigrant 'ghettos' studied by Vaughan (see chapter 2 for an extension of this work into a study of urban poverty). The question was: how is it that areas of concentrated immigrant settlement by choice, such as London's East End, had the ultimate successful outcome of dispersal and integration. Analysis of a range of social variables, such as household structure, occupation, poverty status – as well as communal activities such as the location of religious institutions and social organisations, found a clear spatial component in the apparent success of some immigrant groups compared to others. First, the location of naturally occurring immigrant settlements was consistently found to be at the edge of economically active areas of the city – thus enabling immigrants to participate naturally in the broader spatial economy of the region. Second, the internal organisation of the immigrant community was strongly related to the internal spatial logic of the urban area, with the main local streets hosting the communal institutions. This allowed the fluid group of migrants to benefit both from the support of a dense grouping of neighbouring co-religionists and from participation in the spatial economy (Vaughan and Penn 2006, Vaughan 2005). Clarifying such socio-spatial processes shows how facile it is to refer to immigrant concentrations as 'ghettoes'. In terms of both their spatial form and functioning, many migrant concentrations can be virtually the opposite of the traditional concept of 'ghetto'.

To some extent, the process identified in Vaughan's migrant studies also reflects a more general historical pattern in London in which different faces of the urban block were used as a way of organising the relations between different social classes, with the best off on the most integrated streets and the least well off in the most segregated. The effect was that as you moved along the street you pass the same grade of housing, but when you turned a corner it changed. The street alignment was the spatial organiser of the social pattern, not the urban block. This conserved proximity of different social classes in the same zone and permitted some economic interdependence. We call this kind of pattern *marginal separation by linear integration* (Hillier and Penn 1996). It is one of the ways in which cities have allowed people and uses to co-exist in the same area. One effect of this was that the poor became as it were 'contained' in patches and surrounded by better off people. This will be discussed in greater detail in chapter 2.

Conclusion

Space syntax then shows both how spatial patterns can be studied in their own right, and how they can then add a new dimension to social studies of the city, particularly when issues of segregation are involved. The approach is distinctive in two ways: First, space is conceptualised as an active and independent component in the analysis of social patterns. By separating the spatial from the social in the first instance, we can begin to decipher the influence of social factors on spatial form and in turn the impact of spatial form on social outcomes. Second, space syntax analysis works across scales. It is initially based on street-scale data, and this is important as it is at the level at which people experience the city, and where they meet, interact and carry out economic and social transactions. But space syntax is equally able to aggregate from this micro scale up to the most macro, without either losing sight of the other. In this way space syntax is able to

describe spatial and ‘spatialised social’ phenomena not from a ‘bird’s eye view', as is typical in studies of mapped data, but as the emergent outcome of local interactions pertaining, in a variety of ways, to the global scale.

In what follows, we extend this approach to other areas where spatial segregation seems to be part of a social problem. In chapter 2, Laura Vaughan utilises the scale and level of detail afforded by space syntax analysis for detailed studies of Charles Booth’s statistics of poverty in late 19th century London. The study suggests that there is a spatial mechanism involved in the creation of poverty areas which leads on to a strong correspondence between spatial segregation and poverty.

The discussion of urban pathology, as in the case of the housing estate above, is continued in chapter 3, where Lars Marcus describes the challenge of moving from a view of segregation as a primarily social problem to a view that segregation is inherently spatial. He also illustrates how space syntax research can inform contemporary housing policy by showing the importance of understanding spatial form as a component in problems of social segregation, particularly in relation to the accessibility of public space in housing estates.

We have shown how cities are constructed as gradations of integration and segregation and have suggested that patterns of activity are shaped by the urban grid. Ruth Conroy Dalton describes in chapter 4 the unexpected outcome of designing a relatively integrated golf cart network within a labyrinthine street layout in a low density US city. The increase in available accessibility for the suburb’s inhabitants, coupled with particular social and economic circumstances, has created a virtuous cycle of increased social integration and economic activity. Conroy Dalton’s research provides evidence that changes to the spatial network can have a significant impact on patterns of integration and segregation in cities. As suggested at the start of this chapter: she shows that urban segregation has a physical as well as a social meaning.

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[1] There are a number of measures of the graph which can be used to describe configurational properties of the grid. Hillier et al (1993: 35) describe these in detail: stating that empirically, by far the most important measure is called ‘integration radius n’ or ‘global integration’ which measures the mean depth from each line in turn to every other space in the system, relativised with respect to how deep they could possibly be with that number of spaces, than standardised as shown in Hillier and Hanson (1984). The most integrated spaces are those from which all others are shallowest on average and the most segregated are those from which they are deepest. ‘Integration radius 3’ (commonly described as ‘local integration’), measures the mean depth of spaces up to 3 steps away from each space in turn. Other radii are calculated in a similar fashion (radius 7 – 7 steps away and so on) in order to take account of different areal scales.

[2] In mathematics, the *integration* measure is more familiar as *closeness*, or *closeness centrality*, but syntactic *integration* has a little more mathematics to take out the effect on the measure of the number of elements in the system (Hillier & Hanson 1984: 108-114). The *choice* measure is known in mathematics as *betweenness*, or *betweenness centrality*, though again the syntactic version of the measure is calculated in a slightly different (and to our mind better) way.

[3] In *The Social Logic of Space* the relation between the linear organisation of space and the local *convex* properties, where by definition each point is visible from all others, is also dealt with at some length.

[4] This reverses the customary practice in traffic engineering, where the junctions are the nodes of the graph and the street sections the links.

[5] This work is reviewed in Hillier & Iida (2005).

[6] We find the same result with the simple axial map, but the more recent segment angular analysis is used here for consistency with other illustrated cases.

[7] We could say that just as a statistical data table takes social phenomena out of real space and into logical space, so the addition of space syntax values puts the world of real space and materiality back into the statistics.