SPACE AS PARADIGM
for understanding strongly relational systems

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0 Abstract

This paper examines the methodology of space syntax and suggests that although it begins by defining different types of spatial element, depending on the way in which the system under examination is thought to function, its key feature is that it treats a system of space as being composed primarily of the different points of view from which the system can be seen, as shown graphically in the set of justified graphs, or j-graphs, for the system. The effect is to define each element 'extrinsically', that is, in terms only of its position in the system relative to all the other elements. A useful outcome of this 'method of j-graphs' is that it can lead to the description of emergent structure in large spatial complexes, like cities, which have grown through distributed processes, and through this give insights into both their structure and functioning. This, it is argued, is because, seen spatially, cities are 'strongly relational systems', that is systems in which the complex of relations amongst elements is more important than the intrinsic properties of elements in how they function. Such systems, it is suggested, pervade our artificial world, and include both societies and aesthetic systems. In both, the description of emergent structure in a strongly relational system is a key problem. The paper ends with brief explorations in how the 'method of j-graphs' might contribute to the description of emergent structure in such systems.

Keywords: space, urban, j-graph theory, methodology

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1 Intrinsic and extrinsic properties of space

The spaces that make up a building or urban layout, however we define them, have two kinds of property: intrinsic properties such as the shape, scale, proportions and surface attributes of the space; and extrinsic properties, such as the relation of that space to other spaces, its position in visibility fields, its overall location in a layout, and so on. Intrinsic properties are for the most part what we see when we look at space, and so they dominate our impression of it. Extrinsic properties cannot be seen all at once, but must be pieced together through movement, inference, recollection and so on. Our picture of them is in consequence much less clear.

Surprisingly, although the intrinsic properties of space dominate our experience, it turns out that it is the extrinsic properties that are most critical to the way in which space is used. The reason for this is not immediately obvious, but on reflection it is not hard to find. A spatial layout appears at first sight to be a way of creating a distribution of activities in space, a primarily static concept. This is an illusion of the representation. In real life, the most powerful effect of a layout is to create a system of potential relations amongst the distributed spaces and their activities, which will to some degree be realised through movement. Whatever movement there is will then create an emergent pattern of co-presence amongst those engaged in these located activities. This emergent pattern, rather than the located activities themselves, is what we tend to think of as the 'functioning' of the layout as a whole.

The key outcome of space syntax research both at the building and urban level is that these emergent patterns of co-presence through movement are the primary functional correlates of layout, and that they are predicted by extrinsic measures. Other reported effects of layout, such such the pattern of communications in an organisation (Penn et al), the distribution of land uses at the urban level (Hillier 1996a & b), exploration paths in museums and galleries (Choi 1998, Hillier et al 1996), and even the cultural organisation of domestic space (Hillier et al 1988, Orhun et al 1996, Hanson 1998) - are in some sense downwind of this primary correlate. The secondary effects would not exist if the primary effects from extrinsic variables did not exist first.

2 Internalising human spatiality into the model

This does not mean that intrinsic properties of spaces are irrelevant. On the contrary, they appear in space syntax research as the problem of representation : how is a spatial layout to be represented as a set of spaces in order to capture its functional logic through extrinsic configurational measures ? Experience in fact suggests that such measures work for spatial system only when the representation problem is solved in such a way as to internalise some aspect of human spatiality into the system.

To make clear what this means, we must reflect on what we mean by space. If we follow the dominant tradition in Western thought, at least until the theory of relativity, in which space, is seen as an extraneous framework to the objects that occupy the foreground, we are inclined to think of space as a neutral background to human beings and their activities. The alternative is to see space not as a background, but an intrinsic aspect of what people do. Human activity does not just happen in space. It happens with its own spatial geometry: for example, movement is (locally at least) linear, group interaction is convex (in that those outside a convex field are disadvantaged in interaction, unless of course they are footpads - but that is another local geometry) requiring a high ratio of area to perimeter; while the visual fields that dominate our experience of space have the contrary property that the spikier they are, that is, the lower their area perimeter ratio, then the more interesting and informative they are likely to be.

Space syntax research seeks to capture these 'natural geometries' by using line representations for the study of movement, convex representation for cases were space is more static, and more complex combinations of both when space is both, as in galleries, museums, religious buildings or work environments. The representation of space is a variable dependent on the type of human activity whose spatial logic is sought. The essential research strategy of space syntax follows: to establish by direct observation the factual pattern of space use and movement in a layout, then to try to find the spatial model, formed by combining a representation and an 'extrinsic' measure, whose internal logic can be shown statistically to match that of the space use pattern.

This method has over the years delivered suggestive results across a range of spatial phenomena, and these in turn led to testable theories relating space to some aspect of function. For example the theory of 'natural movement' (Hillier et al 1993, Penn et al 1998), which is now tested almost on a daily basis in the work of the Space Syntax Laboratory at UCL, proposes that if we define an urban street network as a system of lines linking some set of origins and destinations, then to the extent that origins and destinations are diffused throughout the network, and to the extent that movement can occur from all origins to all destinations, then movement along the lines making up the network will be substantially determined by extrinsic measures of those lines. This is then further developed in the theory of the 'movement economy' (Hillier 1996a & b) in which the generative effects of the grid on movement creates preferences for movement dependent land uses for movement rich locations, and the multiplier effects on movement from these choices of the location of attractors then sets in train a dynamic process in which grid structure, movement, land use and building densities become interrelated, and create the pattern of unequal attraction that characterises urban grids that have grown through a step by step process.

2 The method of j-graphs

From a methodological point of view, however, there is a very curious aspect to these results. The 'extrinsic' measures which lead to a theory of movement and land use dynamics seem to be static measures. They describe only the set of relations that hold in a system at a particular point in time, and have within themselves no dynamic aspect. How can they then be involved in, and even predict, a dynamic emergent process ? The answer is the core of the argument in this paper, and it has three stages.

First, in using wholly extrinsic measures, the space syntax method pictures each spatial element not so much as an entity in itself, but in terms of how it sees the system as a whole from its particular position in the system. This is most easily visualised by picturing the system as a system of 'justified graphs'. In Figure 1, for example, we take a simple cell aggregate in which all adjacencies are permeabilities (they do not need to be), and take each cell in turn, mark it with a zero (for 0-depth) and then mark all other cells according to their depth, or topological distance, from the 0-cell. We can then clarify this system of relations from that point by redrawing the cell aggregate from that point as a justified graph, or j-graph, meaning that the root cell is placed at the lowest level, those at depth one at the level above, and so on. The total depth for each cell indicates the degree of spatial 'integration' of that cell in the aggregate, and the total for the whole aggregate, given below each aggregate, and summarised in Figure 2, is the degree of integration in the object as a whole. We may if we wish subject each of the depth totals to the transformations set out in Hillier & Hanson 1984 (and numerous subsequent texts - for a discussion see Hillier 1996a, Chapter 3) to allows comparisons between aggregates with different numbers of cells (and therefore more potential depth), but for aggregates with the same number of cells the totals are adequate.

The implication of this is that the properties we assign to each element are not properly speaking properties of the element but properties of the system seen from the point of view of that element, or, conversely, of how that element is seen from

Figure 1

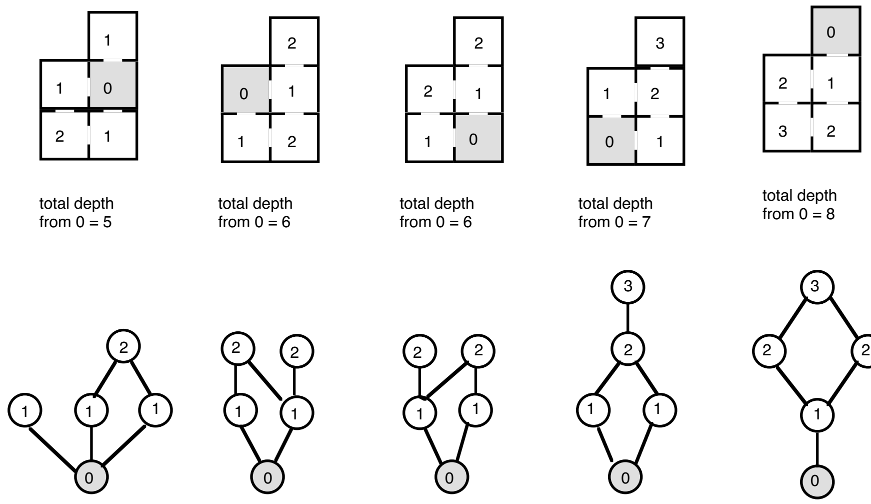


Figure 2

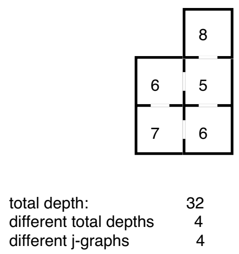
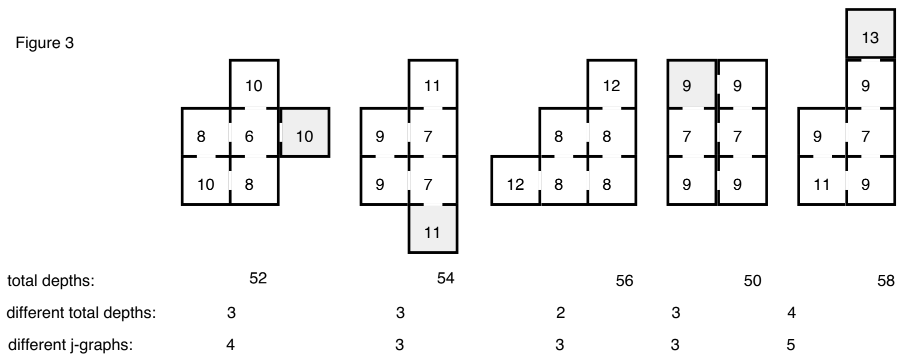


Figure 3



figures 1-3

the point of view of the rest of the system. We may reasonably say, then, that the the real element of the system is not the individual cell, but the j-graph. In effect we have reduced the system to its set of j-graphs. All other properties we assign to elements will be properties of the j-graph. Inspecting the set of j-graphs for Figure 1, we can see that two of the five j-graphs have the same totals, two of the five are isomorphic (the latter does not follow from the former, as we shall see), and that there are the average depth value of the system from its cells is 1.6. These properties of the set of j-graphs are then indexes of the aggregate as a whole, and it is clear that it is not difficult to construct others in a similar vein (see Hillier & Hanson 1984, for example).

The second stage of the answer follows from this. In picturing the system as a set of j-graphs from its constituent elements, we are picturing the element in terms of how it is likely to be affected by the rest of the system, for example, how it is likely to be related to the pattern of movement with its consequent effect on co-presence. The j-graph in effect picture the extrinsic relations which influence that element's role in the overall emergent pattern of functionality in the system.

Third, by expressing the system as its set of j-graphs we build a picture of how the system is constructed from its various points of view, and this turns out to be very useful way of finding and describing the emergent structure in spatial complexes. For example, in Figure 3, we successively add a further cell (shown in grey) in a different position in the cell complex shown in Figures 1 and 2, and recalculate all the measures. The resulting aggregates differ not only in their total depth, that is in their average degree of spatial integration, but also in the numbers of different depth totals from individual cells, and the number of different j-graphs. These differences are not trivial. A considerable body of studies shows that such differences, and how they relate to activities, are a crucial component of domestic space cultures (see Hillier & Hanson 1987, Orhun et all 1995 &1886, and Hanson, 1998).

3 All spatial structures are emergent

The sensitivity of the spatial structure of an aggregate, as shown by its set of j-graphs, leads to a critical conclusion: the global configurational properties of aggregates, that is their configurational properties, as summarised in the set of j-graphs, are emergent from local decisions about adjacency and permeability in the aggregate. Once we see this in such simple systems it becomes clear why the measures are unexpectedly useful in approaching much larger spatial complexes like cities and building complexes. In such cases, the structure of space is clearly emergent from innumerable local decisions about adjacency and permeability. The method of seeing such complexes as sets of j-graphs allows us to capture exactly the emergent properties of complex, and to do so in such a way as to capture something of the logic of the constructive process creating the emergent structure. It also foresees emergent function, in the sense that each j-graph pictures the system as a whole in terms of how it will be functionally influenced by it.

The whole process from local decision about built forms to spatial and functional emergence can be shown through a slightly more complex example. Figure 4a-c shows the first stages of an aggregative process based initially on a simple square cell with an entrance, 4a. A second cell is then joined to the first (4b) on any randomly selected side apart from the entrance side. Two links are then made: one to the first cell through the shared wall (shown as a line from centre to centre), and a second (shown by an equal length line) to the outside through a randomly selected outside wall. Further cells are then added (4c), subject to the same rules. Figure 4d is a stage in the process, and 4e a later stage.

The resulting form show two kinds of emergent structure. The first is to do with built form, and takes the form of a multiple courtyard structure, as shown in 4f. This bears an intriguing resemblance to Steadman's 'fundamental building', as shown elsewhere in this issue (Steadman 1998), no doubt because of the elementary nature of the rules used in the 'restricted random' (Hillier, 1984) generative process. The second emergent structure has to do with permeability, and takes the form of a network of potential routes, as shown in 4g. If this network is then converted into an

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Figure 4

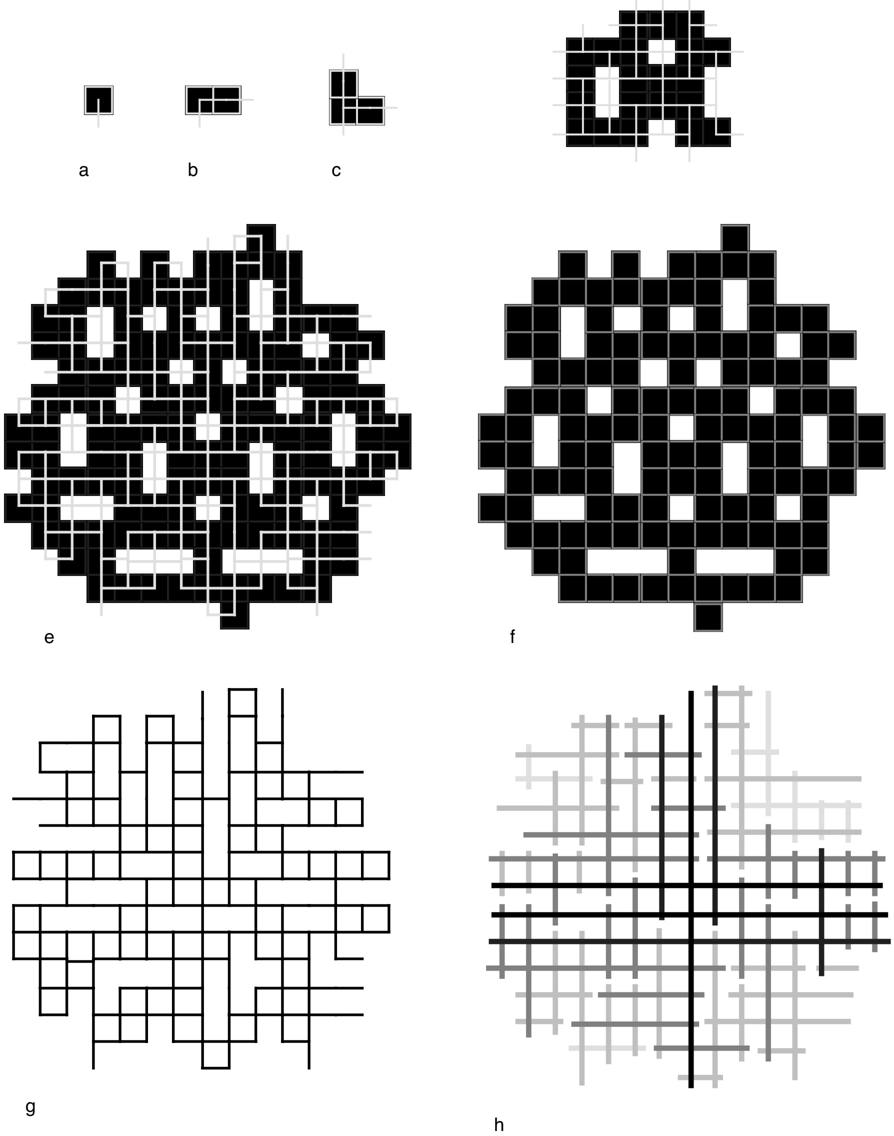

figure 4. a-h

axial map by adding line elements in courtyards where there is no impediment to continued movement along a line, and analysed as an axial map, as in 4h, then an axial structure will emerge which, other things being equal, will have a powerful influence on the pattern of movement in the complex. This in turn, as we have already seen, will create a third level of emergence in the form of the resulting pattern of co-presence in the complex.

We see then how critical the notion of emergence is in the study of spatial systems. Not only are functional effects from spatial configurations an emergent property, but this depends on a prior process of spatial emergence in which, even in simple systems, global configuration emerges from local moves with a local functional logic - closing this partition, opening another, adding a cell, and so on. In expressing the properties of spatial element through j-graphs, which both picture the system from that point of of view, and how that element is likely to be affected functionally by the rest of the system, we are not therefore simply capturing functional dynamics with a static measurement, but capturing the emergent spatial forms of a functionally driven spatial process, and through this recapturing the emergent functional patterns.

It is clear from such examples, as well as from its research results, that the key thing that space syntax analysis does is to provide a description of emergent structure in spatial complexes of all kinds, and through this to provide theoretical insight into their structure and functioning. The variety of measures and representations through which this can be achieved suggests, of course, that these should be seen as structures in complexes not as the unique structures of complexes, and that seen from a different point of view, a system works in a different way. But common to all is the idea that the most useful way to see a system in which complexes of relations play such a decisive role, is as the system of points of view from which the system as a whole can be seen. By representing elements in terms of the whole through the method of j-graphs, we retrieve properties of the whole as an independent entity in itself, that is as an emergent structure.

4 Strongly relational systems

The reason this strategy is both possible and necessary is, it is argued, because urban space is a strongly relational system. Strongly relational systems are those where the pattern of inter-relations amongst elements is more significant for the nature and functioning of the system than attributes ascribable to elements, and where a constantly evolving strongly relational structure creates emergent properties whose description and understanding are the principle problem for a science of those systems. It is argued that this characterisation is not confined to spatial systems. On the contrary, the artificial world in which we live seems to be largely made up of such systems. Societies, cities, and even aesthetic phenomena where the problem of the ensemble is so often the key, all seem in some sense to be both strongly relational and characterised by emergence.

But if such systems are so prevalent, it might reasonably be asked, then why is our understanding of them so poor ? The answer lies in the general problem of the nondiscursivity of configuration (Hillier 1996a). The reason we have to work hard to achieve descriptions of configurations in general is that although we have local relational terms to describe the building blocks of relational complexes - terms like 'next to', 'above', 'two metres to the right of', 'second cousin to' and even 'works for' - we do not have either terms or concepts for relational structures at the level of the whole. Our mental apparatus allows us to intuit configuration, but not to talk about or to analyse it. Complex relational ideas seem to be part of our thinking apparatus rather than our objects of thought. The description of emergent structure in strongly relational systems is perhaps extreme case of the nondiscursivity of configuration. It means that we intuit the complex properties of the distributed world in which we live, but we do not have concepts to bring those intuitions to the level of conscious thought. We grasp our cities and our societies at an intuitive level, but we do not know what it is that we grasp.

The 'method of j-graphs' applied to spatial systems allows us to work towards a conceptual language for emergent structures by transcribing the patterns of numbers indexing the graphs as colours (or, in this text as shades of grey) which allow a 'structure' in the system to be seen and intuited as a distribution of colours. From time to time we try to assign metaphoric terms to describe common structures: the 'deformed wheel' for a certain type of urban grid, the 'shallow core' for a certain type of space structure in buildings, and so on. But in general, the colour patterns, which themselves speak to intuition, take the place of words in giving an intuitive concept of structure in the system.

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What follows is no more than a suggestion as to how we might eventually try to approach distributed, strongly relational systems. It will be confined to one issue: the description of nondiscursive emergent structure. Two cases will be looked at: a simple society, and simple aesthetic judgments. But before we try to apply this to non-spatial examples, one possible objection should be dealt with. All the examples of strongly relational systems we have so far seen depend at some level on the existence of spatial elements forming spatial relations. It is clear that social and aesthetic systems might include, but certainly cannot be subsumed, by such relations. The first step in answering this objection is that we must first show how we can retain the idea of seeing a system as being made up only of the points of view from which it can be seen by 'nearly dissolving the elements'.

In fact, the 'method of j-graphs' does not depend on the spatial representation. For example, if we analyse two dimensional shapes by representing them as tessellations of square cells, the set of j-graphs will reflect area-perimeter ratios through their mean integration values, and the symmetries of the shape by isomorphic j-graphs. For example, in a square shape, each j-graph from a cell, other than those which lie on the axes of symmetry, will have eight isomorphic j-graphs in 'symmetrical' locations (see Hillier 1996a, Chapter 3), reflecting the eight symmetries of the square. Since this will be true under arbitrarily fine tessellations, it is clear that we may retain the usefulness of seeing the system as its set of j-graphs while reducing the 'element' to little more than a position in the system. In other words, we may 'nearly dissolve' the elements, and still retain the essentials of the method as a means of handling strongly relational systems.

figure 5

5 Describing sociality

Few theorists would disagree with the proposition that a key problem in social theory is defining what society is (Campbell, 1981). It is clear what an individual is, and probably fairly clear what a family is, since most family structures, whatever the cultural variability, are based on clear abstract models rooted in 'ancient space' (coitus and birth being spatial events). But a society as a whole seems to be made up of a very large number of persons most of whom do not interact in any obvious way. At the same time, interaction seems to be the very stuff of society, since without it we would all agree that society did not exist. How then can we find structure underlying large, inchoate systems of sparse interaction ? We have, it seems, a strongly relational system (in that relations seem to be more important than the attributes of individuals) but we have no means of characterising, even in the simplest cases, what it is about that strongly relational system that might be named 'society'. For social theory, the problem of giving a description to emergent structure in a strongly relational system, in such a way as to show how it can be perpetuated through time, has a special force, because it is also the existence problem.

We may begin by describing the problem, as it exists for the simplest societies known to anthropologists: small scale hunter-gatherers. We draw here in the remarkable series of papers presented at the 1966 Chicago Symposium on Man the Hunter and published as the epoch-making 'Man the Hunter' (Lee R & Devore I, 1968), and in particular the work of Woodburn on the Eastern Hadza and Lee on the !Kung in that text. We might expect that small-scale mobile societies would both have simple stable forms, illustrating perhaps the fundamental building blocks of human society. We might also expect them to be either a-spatial (since they do not have the fixed relations to place that comes with settlement) or else to manifest simple spatial principles of behaviour such as territoriality. Nothing could be farther from the truth. Simple hunter-gatherer societies do not have simple, unchanging social forms. They form fluid groups, which are both highly variable in size, and which continually change their membership from one season to another, though usually there is an apical woman in each local group. Typically we find such local groups continually exchange people, even on a daily basis, with group joining usually based on kin or affine relationships; solve disputes by fission; are non -territorial (in the sense of a strong identification of groups with particular locations; have different spatial patterns for male and female groups in that hunting is male, larger scale and intermittent, while gathering is female, smaller scale and more or less regular; and have seasonal aggregation and dispersion, often with different cultural traits associated with each state.

So,we must ask, what is being projected through time that could reasonably be called a 'society'. The problem seems clearly to be one of describing some enduring emergent pattern in a strongly relational system. To try to answer the question by pointing to essential features such as particular rituals or social practices misses the point, because what must be described must in some sense be at the level of the whole 'society', not at the level of the means by which 'society' is achieved or perpetuated. We must, it seems, find some reproducible structure in these very highly fluid patterns that we see as the spatio-temporal manifestation of the society. Then we can talk about the means by which this structure is sustained or mutated.

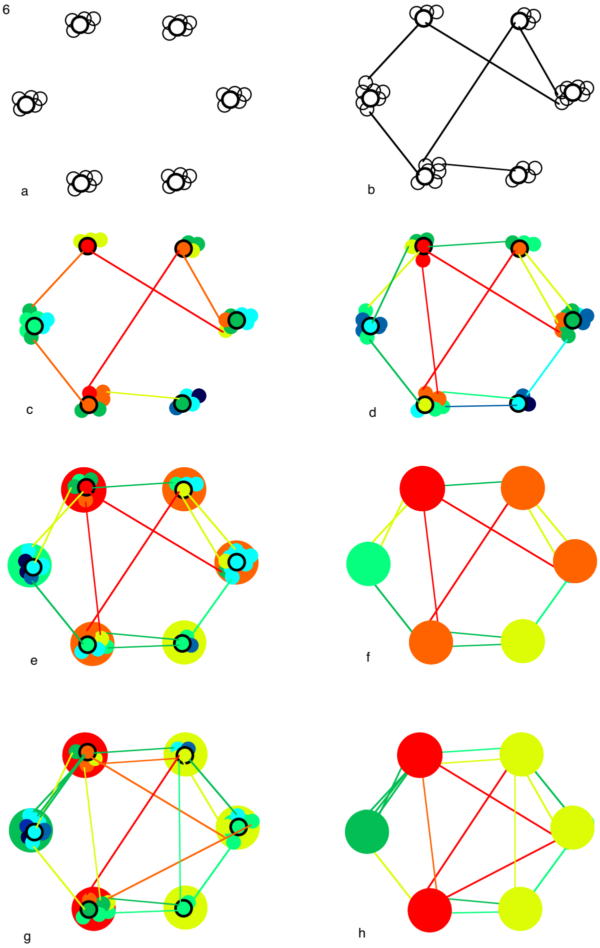
The conjecture is that this might be usefully approached through the 'set of j-graphs' method. In making such a suggestion, we must first acknowledge the long and distinguished history of analytic studies of social networks using graph methods. This work has led to many outstanding results, some of which have been of great use in the study of space (for example Granovetter, 1982), but, so far as is known to the present author, this work has not been aimed at the present target, that is the existence problem through the description of emergent structure.

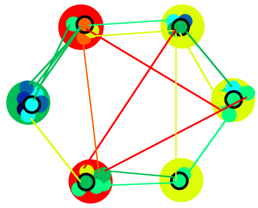
Let us then make a thought experiment (see Figure 6) with the help of space syntax software which allows us not only to link elements to each other by overlapping them, and by drawing lines from one to another, but also to superimpose 'group' elements on clusters of local elements, so that the group element is connected to all the individuals in the cluster. For our hypothetical society, we represent each individual by a small circle, with slightly larger circles for 'apical' women, and overlap the circles if there is shared local group membership (that is, a relation of proximity in the local group, guaranteeing encounters). We begin with six small groups, as in Figure 6a. We then begin to exchange people, one at a time, as in 6b, and each time a person moves from on group to another, we draw a line, not to indicate the movement but the fact that through the move a relation is created between the origin group , where there must be a kin or affine relation, to the destination group, where there must be another. The lines then stand for kin or affine relations across space, realised by movement of a individual to another group. Our overlapping circles and lines thus represent a system with both proximity relation through common membership of the spatial group and relations across space created by the kin-movement relation, in that when you leave one group for another you still retain a kin or affine relation to the origin group.

We can then use integration analysis - that is, measure the properties of the j-graphs of individuals - to analyse the system, as in 6c, in effect expressing each individual as the root of a changing series of j-graphs, and successively analyse the changing pattern as more generations of moves take place, as in 6d. We can also add to the system a covering circle representing the group, as in 6e, and include this in the analysis so that the group acquires its own j-graph and integration value, which can then be shown separately from the constituent individuals, as in 6f. Each individual and each group thus has an integration value which is a function of that individual's or that group's relations to everyone else in the system. Each line linking groups also has a value, even though the line stands for a relation across space rather than a within-group relation. Shading is according to the usual pattern from dark for most integration to light for least.

There is no contention of course that what we see in any sense reflects a real society. The object of the exercise is to show that a structure in the form of a core of integration, composed of more integrated individuals, groups, and even lines, set within a supporting apparatus of less integrated elements, will arise in quickly in such a system, and be describable if not in words then at least in a distribution of colours, as in the case of a structure in a settlement or building. As we continue the same process of random transfer of individuals, the distribution of values changes, with

Figure 6





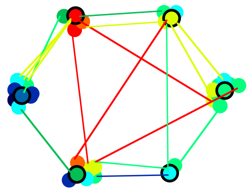


figure 6

individuasl and groups becoming weaker and stronger, but some structure of a similar kind remains. At each iteration of the model we see fluctuations, but the general characteristics of the structure are conserved, as would also be the case for the much slower patterns of change that we see in settlemenst. We have, it seems, described a structure, with conceptual as well as numerical properties. If it has a structure, we can say, then it exists. The statistical properties of the distribution of integration are, it can reasonably be suggested, what we name at any stage as the society, and it is this emergent, gradually changing structure that is perpetuated through time by the social practices of the members of the society.

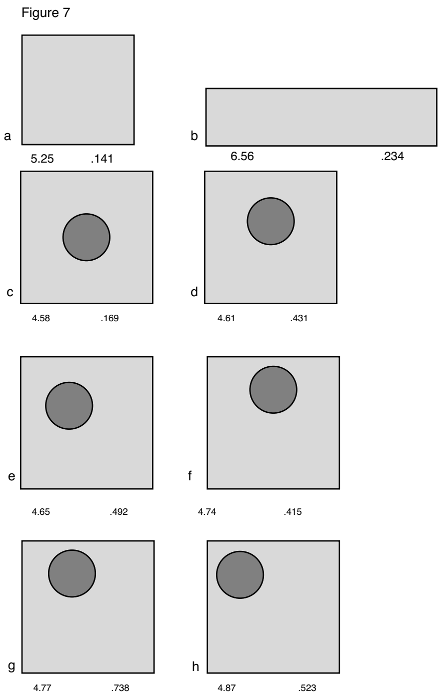
Two important points may be noted about this characterisation. First, we are not naming all interaction as society but the structure deposited by those interactions. Society is not made up of spatio-temporal interaction. On the contrary, spatio-temporal interaction is the means by which the structure is both generated and perpetuated through time. Society is abstract we may say, but it only exists through its space-time realisation. Above all, it is only projected into the future by being realised in space time. Second, social practices are not the society itself but the means by which the structure is recreated and reproduced. Ritual, traditions of exchange of people and so on are not in themselves the society but they are the spatial temporal means by which it is created and the projected across time. The specific dynamics illustrate how a society can be both unstable locally and, through exactly the same mechanisms, achieve greater coherence through greater networking at the global level (Turner, 1957). It is clear that if people stayed in the same groups then either society would have to be integrated in a different way (through beliefs and rituals say) or it would break down and cease to be a society. Exchanging people is one way of overcoming space and prioritising the global network at the expense of the local group.

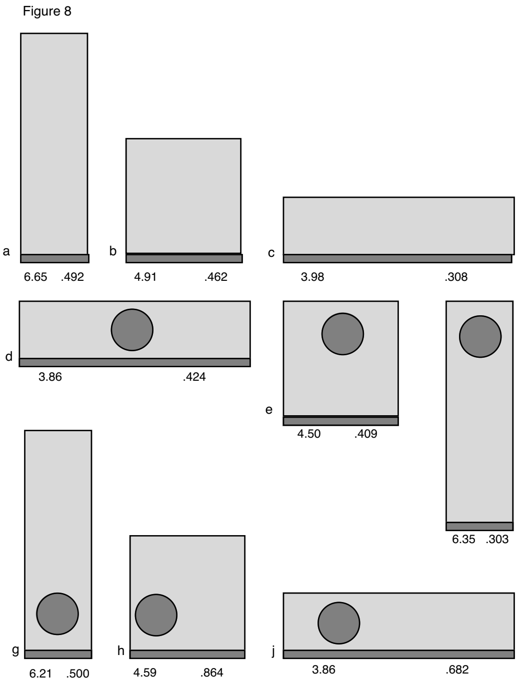
This model is of course purely theoretical, but it does permit the philosophically useful inference of existence from structure. The identification of nondiscursive 'structural stabilities' - to use Rene Thom's expression for entities in general (Thom, 1972) - in the emergent pattern of social interactions and exchanges permits us to conclude that of course the society exists in spite of its nondiscursivity, because we have described its form of nondiscursive existence. If we believe Claude Levi-Strauss's famous observation about primitive societies, then we need do nothing more: 'Each of these (simple) societies' he wrote, 'considers that its essential and ultimate aim is to persevere in its existing form and carry on as it was established by its ancestors, and for the sole reason that its was so fashioned by its ancestors. There is no need for any further justification; 'this is how we have always done it' is the reply we receive without fail wherever we ask an informant the reason for a particular custom or institution. The fact that it exists is its only justification. It is legitimate because it has endured.' (Charbonnier, 1961). The function of a society, in short, is to exist by preserving its form. We must show how this is possible.

6 Seeing strongly relational systems

The second case study begins with a story. I once (a very long time ago) had a crowded mantelpiece, and an enthusiastic cleaning lady. Each week she would take my disorderly array of objects on the mantelpiece and arrange them for me with the largest in the centre, the next largest two at either end, and other objects graded for size in between, thus maximising bilateral symmetry. On arriving home, embarrassed by the symmetry, I would immediately go to the mantelpiece, and 'muss up' the arrangement, restoring some approximation of the original disorder. At least, that's what I then thought I was doing. In fact, I was placing to objects rather carefully, seemingly trying to make the arrangement have as little symmetry as possible. Can this be so ? Or are all arrangements that lack perfect symmetry equally nonsymmetrical. On reflection, I seemed to be trying to minimise or maximise some value. What might this be ?

It has already been suggested that some aspects of symmetry respond to the 'set of j-graphs' analysis. In Figure 3, the various space structures (which could equally be physical shapes, since adjacency and permeability were always identical) varied on three measures: total depth, or the overall integration of the shape: number of isomorphic j-graphs, which, bearing in mind that an isomorphic j-graph indexes a perfect symmetry in the shape, indicate the degree of symmetry; and the number of identical total depths, which indexes the number of cells from which the general distribution of the j-graph, though not its actual structure, is in balance. We might think of this in terms of the balanced asymmetry, by which different shapes but with equal masses are held to balance each other out in a shape. For convenience, let us think of this third measure as indexing the degree of 'weak symmetry', or balanced asymmetry in the shape.





figureS 7-8

Figure 7a and b make this calculation for a simple square shape and a rectangle of equal area. The Figures on the left are the mean depth from each cell, that on the right the number of identical mean depth values for cells over the total number of cell, meaning that the lower the value (between 0 and 1) the more weak symmetry is present (obviously including strong symmetry, since isomorphic j-graphs will automatically have the same total depth), and the higher the number the more. We are interested then in minimising and maximising this value.

Suppose we first consider the effect of adding a single architectural 'figure', in the form of a circular window, to the form. It is clear that weak symmetry will be greatest (the lowest value) when it is centrally placed. But where will this value be at its highest, that is, where can we place the figure to achieve the least weak symmetry, and perhaps, bearing in mind cleaning ladies, most 'counter-symmetry' (if such a thing exists). The results are fairly commonsense, and depend on the degree to which the figure conserves strong symmetry. Figure 7g, in which the figure is placedat the edge midway between centre and corner yields the maximum value.

Now let us complicate the issue, and make it more lifelike by recognising that building facades are not freely floating shapes, but 'oriented shapes' (Hillier 1996a, Chapter 3) anchored to the ground, leading us to read a square shape, say, as a bilateral symmetry rather than an eightfold symmetry. To do this we simply add a linear element to the form representing the earth, a crude way of distorting the form to reflect gravitational realities, but one that leads already to interesting results. Figure 8 The effect on shape is interesting, in that a vertically elongated form becomes quite distinct from a horizontal form. A horizontal form, as in 8c, increases weak symmetry, while a vertical form, as in 8a, reduces it. This is very intuitive. A vertical form is differentiated away from the earth, from more integrated at the base to most segregated at the apex, while the effect of the earth-line on a horizontal form is to make values more equal to each other. A horizontal shape informs us of the similarity of its parts, while a vertical shape informs us of differences.

Figures 8d, e and f then show the locations where the adding of a single figure maximises weak symmetry, and 8g, h and j where it is minimised in the shape. The former are interesting mainly in that in the square form weak symmetry is maximised by locating the figure near the top of the central axis of symmetry, and the same is true in the vertical form. The figure is in effectbalancing the effect of the earth-line. The latter three are interesting in that they suggest where figures might be placed to to minimise weak symmetry, and so antagonise my cleaning lady. At this stage, while formal experiments have not yet been carried out, the reader must decide whether or not these cases seem intuitively to maximise something like the opposite of everyday symmetry.

7 A final conjecture

However fanciful these conjectures, the more solid evidence from the study of space suggests that the ability of the human mind to retrieve descriptions of complex emergent structures without being able to put into words either the structures themselves or the cognitive means by which we know them may be reflected in the way in which complex emergent realities are objectively constructed. Through the method of j-graphs, all the structures we have adumbrated have in common that knowledge of them is based on knowledge of how they are put together. As Piaget said in quite other circumstances: 'To know is to construct or reconstruct the object of knowledge in such a way as to capture the mechanism of that construction' (Piaget, 1969 p.356). It would hardly be surprising if complex relational entities like cities and even societies were constructed in such a way that we could retrieve descriptions at least of the structure of the emergent complexity, and through this interact intelligently, if nondiscursively, with them.

What kind of knowing apparatus could accomplish such a task. It is beyond the skills of the present researcher to even begin to attempt an answer to such a question. Certain requirements are however clear. The key issue seems to be that we deal with relational structures tacitly. In this context, the recent conclusions of Johnson-Laird are at least suggestive. 'Knowledge', he writes in 'The Computer and the Mind', (Johnson-Laird, 1988 p.125-6) 'comes in two main varieties....One sort of knowledge comes from evolution, and its wisdom is built into the processes of the nervous system. This knowledge is not really knowledge at all. It is never made explicit, and it is encapsulated in the computations of a low level module. Such modules neither reveal their mode of operation to introspection nor are much affected by conscious control. The other sort of knowledge accrues during the lifetime of an individual. You have experiences with tables, and you can learn about their shapes and functions, and you can use this explicit knowledge, which is available to introspection, to deliberate about the identity of an object.....The distinction between the two sorts of knowledge may mark the boundary between pure perception and cognition. Marr drew the boundary between the two and a half dimensional sketch and the three dimensional model. The neuropsychological evidence suggests that the boundary could be drawn between the three dimensional model and the identification of objects and their functions'.

In other words, between syntax and semantics. For Johnson-Laird, this means between knowledge of the construction of objects and their identification as objects of a certain class. However, for emergent structures in strongly relational, nondiscursive systems where the easy passage to identification permitted by semantic classes is unavailable, we are as it were stuck in the syntactic domain. We are left with the task of trying to describe what we might call the relational shapes of complex things, which can never be seen all at once, and to do so without the help of the shape recognition devices afforded to us by language. In such a situation, we have only the strategies of science available. It is surely a peculiar science which takes the emergent products of the lowest level of our cognitive system (if so it is), that is, our intuitive knowledge of elementary relational schemes, and tries to create out of these a high level language through which to retrieve descriptions of scarcely imaginable emergent complexity. Nevertheless, this may be our task.

Whatever the case, it is clear that the task is a syntactic one. In approaching complex emergent structures in strongly relational systems, syntax is the only game in town. This at least chimes with the prime lesson from the study of human space at UCL: that syntactic knowledge is primary, and semantic secondary, in the ways in which we construct and interpret its complex realities. The spatial pattern itself is the primary source of whatever it is that we might eventually call meaning in such systems. It may be that this also underlies the way in which we create and cognise our social and aesthetic worlds.

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