Between Social Physics and Phenomenology: explorations towards an urban synthesis?

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Abstract

In recent years, both phenomenology and social physics, which might be thought of as occupying the humanistic and scientific poles of urban discourse, have taken an interest in space syntax as a means of furthering their academic aims. Here we suggest that this could presage a far deeper theoretical integration of the multi-disciplinary study of cities than either currently envisage.

1. The view from the bridge

Cities are large physical objects animated and driven by human behaviour. By far the most interesting and difficult questions about them are about how the two connect: exactly how is the physical city linked to the human city? Since the human is on 'either side' of the physical city, in that humans both cause it to exist and then act within the constraints it sets, the question divides into two, one antecedent to, the other consequent on, the physical city. The antecedent question is: how do cities emerge from decades or centuries of human activity and thought as more or less well ordered systems, with differentiated parts and making some sense as wholes, without a 'guiding hand'? The consequent question is: what are the consequences of the physical form of the city for its human form, that is the patterns and dynamics of the economic, social, cultural and cognitive life that goes on in the city.

Both questions are about self organisation, so involve time as well as space. Both are theoretical, but also underpin all design and planning practice. So in city studies, these are the paradigm questions. Every discipline which aims to *theorise* the city as a socio-physical system - and a remarkable feature of urban studies is surely how many disciplines there are - must define its paradigmatic bridge between the human and physical city. We can say 'paradigmatic', because how the bridge between the human and the phsycical is conceptualised is probably the defining feature of the paradigm of study, and consequently of what aspects of the urban complex are defined as interesting, and how study is to proceed.

With important exceptions, such as (Rich & Wallace-Hadrill 1991), most studies of cities are anchored on one side of the bridge. Social science studies commonly focus on the complexities of social and cultural behaviour without seeking to describe or understand a parallel complexity in the city as object. Architecture takes the physical city more seriously, but usually at the cost of simplified view of the human and social side. 'One side' studies often have enormous value, but the development of a *theory* of the city depends on 'the view from the bridge' from which both sides can be seen with the comparable clarity. We could reasonably call approaches to the city *theoretical* if they try to define a bridge.

Historically, the aim of space syntax was to construct a bridge between the human

and physical city. Through the study of the precise spatial form of cities, it aimed to show how the physical city both embodies and shapes the human city. It is not of course alone in this. The approaches to the city we might group together as 'social physics' (see below for a definition) see the physical city as emergent from aggregated human behaviours, and so define a bridge. In a quite different way, phenomenological approaches seek to show how the physical city is reflected in human experience and behaviour, and so also defines a bridge. Social physics and phenomenology are of course at the opposite poles of urban discourse, in that one sees itself as the natural science of cities, the other as humanistic and deeply sceptical about what it calls 'positivist' science. But each in its own way has a view from the bridge.

The starting point of this paper is that in recent years, in spite of their radical differences, both social physics and phenomenology have sought to engage with space syntax as a possible way of furthering their aims. The aim of the paper is to examine the interest of both, as embodied in particular in papers by Batty and Seamon, and suggest that this could lead to a more interesting outcome that either at present envisage. It could outline the shape of a common bridge linking the scientific and humanistic study of cities to each other. Space syntax, it will be argued, challenges certain paradigmatic assumptions in each discipline, but in doing so also brings to light common threads linking one to the other. Perhaps bridge builders have more in common than their view of the world might suggest. In this paper we argue that this is so.

2. Social physics, phenomenology and the city

Social physics can be broadly defined as the idea that social and artificial systems are best studied through the methods of mathematical physics. Historically, the phenomena that inspired the idea were statistical regularities, such as Gaussian or rank-size distributions, in the aggregate behaviour of discrete entities, which are not given in that of any individual entity. Although periodically unfashionable, social physics has had a considerable revival in recent years, largely through the growing science of networks. This has brought with it a focus on the structural, as well as statistical, properties of networks, for example the 'small world' networks which combine local clustering with overall sparseness and short mean path lengths from any individual entity to any other. (Barabasi et al. 2004)

In the urban field social physics can, without undue stretching, be said to include the much older 'urban modelling' movement in which Newtonian physics and statistical mechanics have always been the key paradigmatic and mathematical influences. Alan Wilson's recent 'Complex Spatial Systems' (Wilson 2000) provides a lucid review of this field, and shows how the classical texts of spatial and urban geography can be brought together into a coherent 'interaction-location paradigm', on the basis of a range of concepts and methods derived from mathematical physics, but without much reference to the emerging network science. For our current purpose of examining theories of the city, we might reasonably think of traditional urban modelling, as embodied in the 'interaction-location paradigm' as $social\ physics_1$, and the more recent explicitly network oriented studies, as, for example, outlined in Batty's recent 'Network Geography', as a move towards a $socialphysics_2$, reflecting their order of development.

In urban social physics, the city, or system of cities, is to be explained as the outcome of physical and spatial processes driven by generic or universal human behaviours. For the most part, behaviour is economic behaviour, which acquires a spatial dimension largely

through *distance* as a constraint on economic behaviour. In this sense, urban social physics seeks to find the physical city as the complex spatial output of simple human behaviours, with the bridge defined as the spatial implications of economic behaviours, and the spatial defined as distance. The human side of the bridge is then both pervasive and minimal, and takes the form of assumptions. The human behaviour that creates the city is not something to be explained, since what is to be explained is the physical and spatial city itself. By making assumptions about behaviour, the elementary links between the human and the spatial are defined, which can then drive the physical and spatial processes that create the city. We can perhaps say that, in its theoretical stance, social physics minimises the human side of the bridge in order to maximise the focus on the physical. But it does have a bridge from one to the other.

The driving idea of phenomenology is that there exist connections between minds, bodies and worlds which are independent of the conceptual frameworks imposed by society and by science, and which are in fact likely to be obscured by these frameworks. The aim of enquiry is to identify and isolate these connections, and so free our understanding of the relations between minds, bodies and world from these abstract frameworks. While never unfashionable, phenomenology has also had something of a boost recently through the emergence of the concept of the 'embodied mind' in cognitive science, which has been seen to give a new and more scientific impetus to the paradigmatic denial by classical phenomenologists such as Merleau-Ponty of the mind-body split, and by Heidegger of the mind-world split. (for example, Lakoff & Johnson 1999) In contrast to the anti-scientific tenor of most twentieth century phenomenological practice, the reformulation of some of its basic propositions in scientific terms might for our purposes here be usefully through of, in parallel to social phyics, as $phenomenology_2$, in contrast to the older, more purely philosophical $phenomenology_1$.

$Phenomenology_1$, which still dominates urban phenomenology, has always sees the city first and foremost in terms of the complexities of human experience of the city, arguing that without an account of this, the city makes no sense. The complexity of the city must in some sense be a mirror of the complexities of experience, and vice versa. Phenomenology then also proposes a bridge between the human and physical, one which aims to be more thoroughgoing than social physics, but is at the same time much less clear. In reaity, it tends to be as strongly anchored on the human side as social physics is on the physical side. We can say that, in contrast to social physics, phenomenology maximises the human and minimise the physical in its paradigmatic stance. But, again, it does have a bridge.

Both social physics and phenomenology, insofar as they appear in urban studies, do so as branches of wider enterprises which see themselves as aiming at the deepest and most general level of explanation of phenomena. Both are interested in the city because it connects the human and the physical in ways which seem intrinsic to its form and functioning. But there the common ground seems to end. For social physics, because cities are fundamentally physical systems and the relation to people is made through generic behavioural assumptions or collective behaviours, a mathematical approach is in effect made possible by using the human being to set in motion and constrain the physical processes which gives the city its form and functioning. This view has yielded many remarkable results, and in recent years, has generated an approach in cities can in useful senses be compared to which physical, biological, social and even cognitive systems for example through the pervasive presence of scale free networks which are found in physical and biological as well as social and spatial systems.

Phenomenologists see a different city. The fundamental urban phenomena are human

experiences of the city, and the physical and the human city are not at arms length, but form an *'indivisible whole'* because *'each makes and reflects the other'*. (Seamon 2001) From the human side, people are not subjects reacting to objects, or minds cognising worlds, but *'experiencing beings whose actions, behaviours and understandings always presuppose and unfold in a world that is, in turn supported by and a reflection of these actions, behaviours and understandings'*. (Seamon op.cit) Not surprisingly, phenomenologists tend to prefer a qualitiative rather than quantitative research style, one that *'seeks to describe the underlying, essential qualities of human experience and the world in which that experience happens'*. (Seamon op.cit)

3. Parts and wholes

Of course, social physics and phenomenology barely acknowledge each other's existence, and if mention is made of the other, it is usually brief and disparaging in the academic manner. Unfortunately, the righteous isolation of the two disciplines from each other is reinforced by a fundamental fact of the city: cities exist and function as physical wholes, but are experienced only a part at a time. In seeking to give a physical account of the city as a physical whole, social physics seems satisfied to give a poor and rather abstracted picture of the detailed parts, (and so offers little help to designers) since that is seen as the realm of urban experience, not the realm of urban dynamics. To some, this might seem a curious omission, since any scientific account of how the macro structure of the city is generated through human processes could be expected to give at least some picture of microstructure.

The neglect of the parts by social physics is however complemented by the phenomenologists neglect of the whole. Because phenomenologists are preoccupied with experience, they are by definition preoccupied with the parts, and seem satisfied with a picture of the physical whole as abstracted as the social physics view of the parts. This seems equally regrettable. Although we experience cities a bit at a time, our sense of the city does not reflect this fragmentation. On the contrary, our sense of a city is made up of a sense of its differentiated parts and the transitions between them. It would be too obvious an error to confine the experiential study of the city to the study of its parts. The defining dimension of our urban experience is of how the parts form some kind of complex whole. This is what we mean when we say 'Boston', or 'London' or 'Sydney'. The greatest phenomenologal puzzle about the city is perhaps what we mean by these names.

The fact that cities exist at one scale, but are experienced at another, helps trap us between an objectivist and rather abstracted view of the city as a whole and a subjectivist and phenomenological view of its parts. From the point of view of building a theory of the city, these two polarisations - between the physical and the experiential, and between the local and global scale - seem the wrong way to go. If we think either of how the self-organising city comes into being as the product of innumerable human actions guided by thought, or of how cities work as complex networks of spatial and social differentiation and dynamics, then it would seem, that we must give an account of the physical in terms of the experiential, and vice versa, and the local in terms of the global, and vice versa.

4. Finding the bridge

So we need to find a bridge between the social and the physical which is at the same time a bridge between the local and the global. A possible starting point for the syntacticist might lie in the observation that in spite of occupying the paradigmatic extremes of urban research, social physics and phenomenology have one thing in common: in approaching the city, they start with the human and aim at the physical. In both disciplines this seems commonsense: whatever the mechanisms by which the human is linked to the physical in cities, the order of causation must surely be from the human to the physical because cities are human products. Human behaviour can surely not be the product of the city. We will see below that this apparently innocuous assumption is far from self-evident.

In contrast to both, space syntax starts with the object and examines it for evidence of order resulting from human behaviour. It therefore makes no assumptions about human behaviour but *looks for evidence of human behaviour in the object*. By examining the city, for example, it finds that the human behaviours that gives rise to it are *diverse* - for example the dual micro-economic and socio-cultural processes that create the dual city of public and residential space (Hilllier 2001, 2003). Space syntax would argue that although there is no problem with the idea of making behavioural assumptions and conducting experiments to see how they produce emergent spatial patterns, you cannot impose behavioural assumptions as the sole conditions of a theoretical model and expect the result to be a science, since the model is already an expression of a theoretical position which it in no way proposes to test. Space syntax also studies human behaviour - movement patterns, land use decisions, and so on - to see *how far evidence can be found in their distributions of the influence of the object*. In both senses, space syntax seeks an integration of the human and the physical by seeking evidence of each in the form of the other.

What then has been the grounds for the interest in space syntax from social physics and phenomenology? In each case, the interest has been mainly methodological, but also a little theoretical. From social physics, Batty, while offering many technical criticisms of space syntax, has written a series of paper in recent years proposing, in one way or another, a reformulation of space syntax methods. (Batty 2003, 2004a, 2004b) But he has also used an essentially syntactic argument to criticise geographic information systems (which, while not part of social physics, has taken the social physics paradigm to make links to urban modelling), arguing for a 'network geography' and accusing GIS, which increasingly provide the basic technology for urban systems research, of being *'...the geography of locations not relations...the geography of place in an absolute sense, represented by points, lines and polygons which enable attributes to be associated with these geometric objects, attributes which are largely unordered.'* This happens because *'the representational basis of GIS largely avoids even the most rudimentary distortions of Euclidean space as reflected, for example, in the notion of the network.'* He cites space syntax (though he does not quite bring himself to refer to any space syntax texts, and bizarrely assigns the invention of the axial maps he has so often criticised to Desyllas) as the only case where a network representation is used to order spatially located phenomena, with the effect that what *'... might appear to be a random distribution of activity in Euclidean space is often seen as being highly ordered on a network.'* This is the fundamental proposition of space syntax inscribed in the social physics paradigm.

In the explicitly syntactic papers, Batty seems mainly concerned with reformulating space syntax in a way which make it more tractable to the established formalisms and theoretical practices of social physics and geographical information information systems.

But there is also a theoretical angle, in the form of an acknowledgement that the syntactic focus on the configuration of spatial *networks*, which is at best implicit in social $physics_1$, could usefully become a more explicit variable in social physics approaches. This is a little late in the day but not surprising. Outside cities, social physics focuses increasingly on networks and their structures, and it seems less and less obvious that the primary physical network of cities, that is the street system which links the parts into a continuous whole, should be treated only as a secondary and in most instances partial variable in urban modelling and geographical information systems. In spite of numerous criticisms of the syntactic approach, there seems to be an acknowledgement that treating space an a explicit and independent variable has brought to light a concept of spatial structure which links the finer and larger urban scales, and at the same time shows it to have real *agency* in the dynamics of the system.

From the phenomenological side, the idea that space syntax could be usefully seen in phenomenological terms was initiated by Seamon (Seamon 1994). He began by criticising those who discard space syntax *'through the inaccurate charge of environmental and architectural determinism'*, and asked why space syntax might be of interest to phenomenologists when *'...it is positivist conceptually, and emphasises aggregate measurement, quantitative validation, and societal-spatial structures...'*. His answer is that space syntax addresses key issues of central interest to phenomenologists: it *'demonstrates once and for all that the built environment, particularly through its spatial qualities, plays a significant role in supporting a lively street life...'* It *'...uses quantitative evidence in such a way that the student can see clearly why the relationship between the physical and human worlds makes such a difference'*. It *'...identifies the type of street network that supports a lively street life'* and more generally *'...goes far in helping one understand how the dynamic between environmental order and serendipity fosters place and community'*. Seamon proposes phenomenological studies to complement to space syntax: studies of street networks *'...experientially in terms of everyday experiences, behaviours, and events that are supported, especially the relationship among physio-spatial qualities, pedestrian movement, chance encounters, informal sociability and form social structures.'*

We suggest that both arguments can be taken much further. We argue that these overtures could presage a potentially far deeper integration of the physical and human subject matters of cities. Social $physics_2$ is about network emergence and network agency, which do not feature significantly in the social $physics_1$ paradigm. $Phenomenology_2$ is about how mental structures and behaviours reflect regularities - and even laws - in the real world, and this is not represented in the $phenomenology_1$ paradigm. Space syntax suggest that cities, both in their form and in their functioning, are *fundamentally* emergent spatial networks, with autonomous structure and agency, and that neither the antecedent nor consequent questions about the relations between then human city and the physical city can be answered without the concepts of network structure and network agency. It has also now been shown (Hillier & Iida 2005) that the relation between the physical and human cities depends on a *phenomological concept of distance*, in that topological and geometric intuitions are used by human minds to form pictures of the complex spatial networks in cities which are both the product of human aggregate behaviour and the means by which we interact with them. In this sense space syntax exactly combines social $physics_2$ and $phenomenology_2$ into a single theoretical model of the city as a human-physical system, and so offers a unified paradigm within which the scientific and humanistic dimensions of cities can be studied within the same framework.

In the remainder of this paper, I will suggest that we cannot have a theory of the

city which does not bring the concerns of social physicists and phenomenologists into a single theoretical framework, and that the closest thing we have to this is the theoretical framework of space syntax itself. In what follows I explain the underlying theoretical preoccupations of both phenomenology and social physics, and suggest why both can be met, to the theoretical advantage of each, and without too much strain, through the theoretical and methodological framework of space syntax.

5. What is phenomenology really about?

The origins of twentieth century phenomenology lie with Edmund Husserl and his manifesto for 'Philosophy as a Rigorous Science' (Husserl 1922). In spite of the title of the founding text, phenomenology is usually associated with an anti-scientific stance, and it is important to understand why it in very foundations phenomenology implied a critique of science. It is also important to understand that its relation to other currents of thought in the twentieth century, with its unprecedented diversity of movements, sub-movements and counter-movements, may be more easily understood through its anti-scientific stance, than through substantive ideas. There are perhaps fewer philosophical ideas than there are names for them. In what follows, I draw on Seamon's own review of the phenomenological literature addressed to *'...place, environment and architecture'*. (Seamon 2000), on a recent paper by Paul on the work of Husserl in the foundations of the 'social systems' theory of Luhmann, as well as on the more general picture of the emergence and transformation of phenomenological thought in the twentieth century as found in the classical review of Spiegelberg (1965).

According to Seamon's excellent review (Seamon 2000), two assumptions characterise phenomenology throughout its many transformations in the twentieth century. The first is the idea *'that mind and world are indivisible'*, the second a *'radical empiricism'*. Why these two notions are at the heart of phenomenology can best be understood through the problem situation, as Husserl saw it, which prompted his phenomenology. German philosophy at the end of the nineteenth century was dominated by Neokantianism which, in Paul's terms, *'sought to defend philosophy ... against the practical, technology related knowledge and above all against the experimental method of the natural sciences'*. (Saul 2004) Science was seen to have explained the objective world, but in ways which detached that world from human experience by reformulating it in terms of the abstractions of data and equations. But human life is meaningless without the world from which the mind has been detached by science, and so philosophers cannot make sense of life without an account of the world. If there is to be a philosophy, then, - and, dare we say, a living for philosophers? - the world must be saved from science and reformulated in terms of human experience. Hence the link between mind and world and the radical empiricism are in the very foundations of the phenomenological idea, and the critique of science not an epiphenomenon, but intrinsic to its very foundations. To drive the point home, Husserl argued that on the basis of phenomenology, it would be possible to rewrite all the sciences on the basis of an *'a priori science ... intended to supply the basic instrument for a rigorously scientific philosophy and, in its consequent applications, to make possible a methodological reform of all the sciences'*. Husserl was nothing if not ambitious.

How the 'rigorous science' was to be realised and what form it would take varies between different schools of phenomenology, but the core project is to save the real world that we experience from the violence that is done to it by science. In this sense, the phenomeno-

logical project is unintelligible without the critique of science. In Husserl's foundational texts the project was to take the form of a search for invariant structures which link the subjective and objective world, as Spiegelberg says *'...the essential - i.e the objective or absolute - structures in what would otherwise be merely subjective phenomena'*. In this sense, Husserl's phenomenology is not subjective but reflexive. Structures or essences are to be identified not by introspection, but by the critical contemplation of phenomena as they present themselves to human experience with the aim of detaching the essential features of phenomena from the obscuring networks of theoretical preconcpeptions which currently mask them. The method for doing this will be a suspension of the *'natural attitude'*, through which we take for granted the categorical and theoretical picture of the world inherent in commonsense and its derivatives, such as science, in order to access the essential phenomena which are given to pure perception and on which our categorical and theoretical constructs have all been built.

We may then usefully draw a clear distinction between the aim of phenomenology and its method. Stated as simply as the search for invariant structures which link the subjective and objective worlds, it is hard to disengage this idea from others to which, in the orthodox histories of philosophy, phenomenology seem opposed. For example, it clearly links to Karl Popper's notion of a 'third world' of *'real abstractions'* with their *'objective logical (as opposed to visual) contents'*, which are the means by which the first world of subjective experience interacts with the second world of physical states, and through Popper we can see the route back to Plato with his preoccupation with the 'intelligible' forms that make perception possible in the first place. (Popper 1972) Of course, Husserl, unlike Plato, stresses the primacy of perception, but this is methodological, since if and when Husserl succeeds in accessing the invariant structures underlying perception, then it is hard to see that they will not be clearly seen, Plato-wise, to have made perception possible in the first place.

It is similarly difficult to fully separate Husserls fundamental concept from the core structuralist notion of the 'rule governed creativity' through which the great variety of human cultural behaviour and experience are linked by generic abstract forms which have their ultimate origin in the nature of the human brain and the way it shapes the world which human beings create, and interpret the world given to them by nature. Husserl even shares the problem common to both Popperian third worldism and structuralism: that of locating these generic 'real abstraction' structures somewhere in the universe that is not simply the human mind.

At this level, Seamon shares the underlying Husserlian project, but later versions of the project make fundamental changes, which are also vital to Seamon. While with the location problem unresolved, Husserl's essences were to be discovered as features of *consciousness*, Heidegger sought to re-locate them in *experience* and so tie consciousness to the phenomenal world in a way that Husserl had not, and unify subject and object into a single system. This is what 'being-in-the-world', or Heideggerian *dasein*, is about. Merleau-Ponty took this another step by linking experience to the body as well as the mind, and in doing so sought to obliterate the mind-body distinction as Heidegger had sought to obliterate the subject-object distinction. Again, it is not clear how these notions can, other than in intellectual style, be clearly distinguished from similar more scientific formulations, such as those found in 'embodied mind' cognitive studies, in which the mind is not free-floating and independent of the material world, but, by virtual of being embedded in the body, inextricably linked to how we act in the world.

It does not then seem to be the intellectual aim which clearly distinguishes phenomenol-

ogy. Perhaps then it is the method: the 'radical empiricism'. What exactly does this mean? Seamon's answer is clear. Phenomenology is *'... the exploration and description of phenomena, where phenomena refers to things or experiences as human beings experience them'... not for '...idosyncratic descriptions...'* but *'...to use these descriptions as a groundstone from which discover underlying commonalities that mark the essential core of the phenomena'.* So phenomenology aims, by careful examination of phenomena, to arrive at a picture of the invariants underlying those phenomena. At this moment bells begin to ring because what Seamon seems to be describing is the programme of any science - without the maths to be sure, but science all the same. Any science, or indeed almost any other kind of directed human enquiry will be searching for the invariants in some range of phenomena. There is nothing else for a science to do. Of course we must add the 'phenomenological rider': that these invariants must be seen to be common to the world itself and human experience of the world, and so unite the study of subjects and objects, people and things, into a single framework. However, it is not clear that this can be clearly distinguished from any project that seeks to find the invariants that link human experience and action in the world to the form of the world itself, and several strands of twentieth century thought, including space syntax, have sought to do exactly that.

Seamon himself has of course already said as much as far as space syntax is concerned. His 1994 paper suggested that space syntax is already in some sense a realisation of the phenomenological programme. But in that paper his principle observations were about the ways in which space syntax shows how the structure of real environment shapes human experience and behaviour. He does not go so far as to suggest that space syntax - with perhaps its own form of radical empiricism - is a realisation of the objectives of the founders of phenomenology: to show that there is a common framework to subjects and objects which unifies them, if not exactly into a single system at least two ways of looking at the same thing.

6. Space syntax in the light of phenomenology

So let us examine the theory of space syntax, as it currently stands, in the light of this possibility, by recuperating the standard lecture I give on space syntax. This starts by observing that since many have denied the existence of space, and most deny its autonomy - how can human space be autonomous when it depends for its creation on physical objects such as partitions, boundaries and so on, and these in turn depend on human intentions? - we begin by showing that as soon as space is seen *relationally* it can be shown to 'really exist' in some sense. If spaceb is between spacea and spacec then this relational complex is real in at least as strong a sense as that an object with a planar surface resting on four legs is real (and so legitimises the common description 'table'), since we must pass either through b or some other intervening space to get to c from a. We can say that the arrangement has structure (Popper's objective logical contents), through the relation of bertweenness, and agency, in that we *have* to go through this space to get to that one, and therefore it exists.

We then show that merely placing objects in space leads to configurational properties emerging in the ambient space through the operation of simple mathematical laws - for example, an object placed centrally in a space obstructs movement and intervisibility from all points in the ambient space to all others more than if the object is placed peripherally. We argue that from an early age people seem to acquire an intuitive feel for these laws,

in much the same way that we acquire a feel for the laws of mathematical physics so that we can throw a sufficiently scrunched up ball of paper in such a way that its parabola leads it to land in a waste paper basket. Through intuitive knowledge of these laws, even young children learn to manipulate space for social ends, and this manipulation depends on space behaving in a predictable and lawful way. Certain laws of space are then common to mind and world.

So in the very foundations, we have found a profound link between the world itself, and how our 'minds' work in relation to that world. It looks very Husserlian, in that it takes the forms of irreducible abstractions which are common to both world and mind and make us as 'embodied' in the ambient space as much as we are in the physical world. Moreover, we have learned these irreducible abstractions by acting bodily in the world and experiencing the effects, and then converting these into abstract principles. In this sense, the Heideggerian and Merleau-Pontian programmes also seem to be satisfied.

But the next step is even more important. Because our spatial intuitions are shaped by the laws of space, so that we can manipulate space for social ends, the ways in which we create the real patterns of complex space which we inhabit reflects these laws in very specific ways. First it specifies an envelope of possibility outside of which space is not human in the sense that it is neither intelligible to human minds nor usable for human purposes (Hillier 1996, Ch8), and then within that envelope of possibility it differentiates spatial pathways which in their very formal nature become expression of different kinds of human purposes. Essentially these two pathways are, on the one hand, using space to generate encounter, and so allow morphogenesis both in space and in encounter patterns, and, on the other, using space to restrict or shape encounter in such as way as to conserve existing social forms and structures. This is the syntactic distinction between generative and conservative space, and it is one of the foundations of urbanism in that urban space is generated by the dual process: a public space process which maximise encounter and give rise to the global structure of the city and is more or less invariant because driven by micro-economics; and a residential space process which is culturally differentiated and which create the background space of the city and conserves existing social forms.

Now from a phenomenological point of view, this means that the links between mind and world originally made at the level of laws and intuitive knowledge of these laws, now becomes the means by which the complex structures of space created by human physical interventions, over decades or even centuries, acquire a form which at the deepest level is already deeply imbued with human intuition, experience and purposes. We use the laws to constrain the pattern of emergence and give it shape. More simply, we can say that the human and social content of the environments from which we live comes from the way in which our experience and understanding of space becomes built into the way in which we act in the world. In addition to this, we can express these as abstract and even quantifiable structures, as well as showing their relation to human behaviour in an orthodox scientific way.

What I am arguing here is not that space syntax does all that phenomenology seeks to do. Space syntax gives a partial and incomplete view of the relations between human beings and their created environments, and, if I understand it correctly, modern phenomenology is very concerned with the full richness and diversity of human experience of the environment. What we do show is that there are very deep two-way structural links between the forms that created environments take and human ways of 'being in the world', both as bodies and minds. In this sense syntax can be accused of being reductionist - though what account of invariants in phenomena is not of necessity reductionist - but in this it is, it can be

argued, a clear realisation of key aspects of the foundational Husserlian, Heideggerian and Merleau-Pontian programmes. Whatever form solutions took to the basic questions posed by these writers, they could surely only be expressed in a reductionist way.

7. The problem of emergence

Could space syntax then in some sense be argued to reduce to phenomenology? It cannot, for at least one clear reason. There is one pervasive phenomenon in the created environment which is neglected by phenomenology, and may even be out of its range, but without it no created environment or its relation to human beings can be properly understood. This is the general phenomenon of *emergence*. Understanding emergence is vital because even though we act on the environment in ways which reflects the lawful basis of our spatial experience, as well as our social nature, these actions become fixed in the environment for long enough to ensure that patterns emerge in that environment which, although shaped locally by our intervention, are *not globally accounted for by it*. The emergence of global patterns from consistent - or consistently varying - local behaviours happens according to laws which are independent of us, with the effect that the environment we have created comes to confront us as something new and unfamiliar, even thought we have created it. This is most simply shown in the beady ring process, which Seamon discusses, but is true of virtually all towns and cities. Most, and perhaps all, cities are partially ordered systems, created out of a mixture of the local ordering which we place on them and the global patterns that emerge as a result of these behaviours. The first puzzle of human settlement is how regular, workable and orderly large scale - and to some extent invariant - global patterns arise from innumerable local human actions carried out for different purposes is different social conditions.

How large scale patterns emerge from local actions is as much a part of the space syntax research programme as is the search for invariant spatial laws linking mind and world. Syntactic emergence has been identified at three levels: the emergence of large scale spatial patterns from the placing of buildings, and here the laws linking world and mind are primary; the emergence of large scale patterns of movement from large numbers of local nagivational decisions; and the emergence of urban life and activity patterns from the conjoint effect of spatial networks and movement within them. It is difficult to see how either of these themes, both of which are vital to a theoretical understanding of cities, could be formulated in phenomenological terms. Both are focused at spatial scales which are well beyond immediate intuitive perception, but confront perception with phenomena which originate partly through the work of minds and partly through the action of worlds, and so challenge the ability of minds to grasp the order of the ambient world. What, we might ask, is the purpose of a radical empiricism which cannot deal with the fundamental emprical fact of cities: the fact that the city as city - that is as 'Boston' of 'London' - is an emergent phenomenon, shaped not only by the mind-intention-action triple, but also - perhaps mainly - by how worlds respond in their own terms to this triple? Cities make cities as much as people make cities.

There is of course no reason why phenomenologists should not address themselves to the problem of real world emergence, but to the extent that they did, then it would seem less and less to be phenomenology. The problem would be exacerbated to the degree that phenomenologists persisted with the notion of *intentionality* as governing relations between mind and world/in here and out there. A key element in the syntax argument

is that beyond the level of relations between two or three things, as embodied in, for example, the prepositions of the English language (words like between, beyond, through, above, inside, and so on, all seem to give accurate topological descriptions of relations between three things, but beyond this level, words either do not exist, or lose precision - for example, 'among'), the human mind deals with relation intuitively, as part of the apparatus we think *with*, rather than *of*. This is why we deal with the relational aspects of language competently without being able to give an account of what we are doing, and the same applies to space.

In other words, the foundational abilities through which we are able to negotiate our relations with a spatially complex world are specifically outside the realm of intentionality. In space, intentionality insofar as it exists, seems to be confined to the more localised - and therefore less complex and less interesting - level of spatial relations. The notion of intentionality re-inforces a preoccupation with the localised point of view, and inhibits a view of the real puzzle between mind and world: how we deal competently with spatial complexity in the ambient world without having much idea what we are doing.

8. Social physics

In contrast to phenomenology, social physics was *initiated* by the phenomenon of emergence, initially in a statistical sense, but more recently, as we have said, through the concept of network, in a structural sense. On the basis of (Barabasi et al 2004) we can suggest that there are two fundamental preoccupations in social $physics_2$. The first is with *network emergence* - that networks acquire emergent structures through the combined effect of specific distributed processes such as people forming new relationships or adding buildings to cities, which are under the control of people, and mathematical laws which ensure that if certain distributed behaviours occur the emergent outcome will be a particular kind of pattern, which are independent of human beings. The second is with *network agency* - that the structures that emerge as the network is created play an independent but critical role in shaping the functional dynamics of the system.

Going back to the two questions about cities which we defined at the start of this paper, we can say then that, from a syntactic point of view, the two question about cities are the two questions of network science. The emergence of network structure is the 'antecedent' question, and the agency of networks is the 'consequent' question. In space syntax, network emergence features as the way in which the configurations of urban street networks appear as a consequence of the aggregation of built forms and of the influence of mathematical laws which link one to the other. (Hillier 2001, 2003) Network agency features as the 'city creating process' by which the street network shapes movement, which then shapes land use patterns which through multiplier effects on movement lead to the modification of the network, and further land use effects, resulting in the characteristic form of the city as a network of centres and sub-centres across a range of scales set against a background of mainly residential space. (Hillier 1999)

But what of social $physics_1$, as found in traditional urban modelling and as generalised i Wilson's 'interaction-location paradigm'? Neither network emergence or network agency feature in the paradigmatic foundations, as they do with space syntax. The foundational ideas derive from an analogy between cities and physical bodies: that movement between pairs of cities is directly proportional to the sum of their masses and inversely proportional to their distance, and so can be expressed in some variant of the Newtonian gravity

equations. The *fundamental* urban mechanism, as seen by urban social $physics_1$, namely *attraction* follows from this, and its fundamental expression is through *distance*. Movement is then a function of attraction as modified by distance, and attraction is defined in terms of scaled masses attached to locations, and, although these represent *discrete zones*, locations are essentially points.

Traditional urban models, or interaction-location models, then typically begin with a definition of discrete zones and the attractive 'masses' they contain. These 'masses' can be very complex, and include retail mix as well as the sum of retail surfaces, or indices of housing quality, and so acquire a psychological dimension, but how attraction is defined does not change the basic form of the model, and nor does the definition of distance in terms of time, cost or impedance. The shape of the model is still attractive masses interlinked by some definition of distance, and the mechanics of the model are defined by this scheme. From a syntax point of view, this definition of the system is theoretically problematical, since it omits any reference to the properties of the system which have generated the pattern of differential attraction: the emergent configuration of the street network itself.

But is it not necessarily that way. Interaction-location models can be used to *generate* patterns of differential attraction. One of the best examples is Ryhll and Wilson's (Ryhll and Wilson 1991) study of the scaling of settlements in ancient Greece. Starting with what they call an 'egalitarian' model consisting only of points in the landscape where settlements are known to have existed, and the shortest straight line distances between them, they measure the degrees of interaction (movement of people and goods) between each and all others initially as a function of distances, but as the system develops, as a function of the changing scale of the settlements. By varying parameters governing the ease of communication and the benefit of concentrating resources they are not only able to give a plausible account of the real scale of settlements (in so far as it is known), but also to show general tendencies in the pattern as the parameters are varied. For example, greater ease of communication or greater benefit of concentrating resources tends to produce more centralised settlement patterns, while the reverse tends to more devolved patterns.

This remarkable paper illustrates something that is rarely discussed in the social $physics_1$ literature: that attraction in cities is something that needs to be explained *ab initio*. But although remarkably interesting, it is unlikely that the Rihll-Wilson model can be generalised. A settlement pattern consists of a set of settlements with different masses or scales, and a network of scaled channels connecting them, with some relation between the scaling of settlement and the scaling of channels. The question is what determines what. A settlement is an event in a network and the most common way of defining the reasons for a settlement and its scale is in terms of a pre-existing network of some kind, as when we say, for example, that a city is where it is due to a confluence of rivers, or an intersection of large scale trade routes, or in terms of access to and from a network, such as a port city built around a natural harbour. Once established, we assume that the growth of a settlement will be in some sense proportional to its position in some network. The location of many large cities at or near the edges of countries is testimony to this, since the largest scale network in any patch of land will be the links to other patches of land.

Any theoretical account of a settlement pattern, then, would need to account for both network structure and scaled masses starting from a pre-existing network of some kind. The effects of generalised distance that Rihll and Wilson have identified are more likely to be constraints on how the system operates rather than causes, so in some circumstances it

will seem to work as a good approximation by itself. But settlement pattern formation is fundamentally a network phenomenon, and in settlement pattern formation the network undoubtedly has agency. In the Rihll and Wilson model the network is a, initially given system of points linked by distances, and the scaling of settlements is produced purely through the as the crow flies distances, as modified by the two parameters. What emerges from the given patterns of points and distance is only the scaling of the settlements. There is no network agency which is not accounted for either by the scaling of the points or the summing of distances. It is more likely then that what Rihll and Wilson have identified are the metric and locational *constraints* on the process of settlement formation rather than its primary generators.

What then of the patterns of differential attraction thay we find within cities. If these patterns can also be accounted for through network agency, then it would follow that attraction cannot be treated as primitive, but should be derived in some way. What evidence is there that the network agency process outline previously does shape the pattern of land use distributions in cities. The syntax argument is that the configuration of the street network which emerges form the aggregation of buildings, in itself shapes movement, and this then shapes land use patterns, and so generates differential attraction. If this is so, then there should be everywhere evidence in cities that this is so in the form of consistent relations between geometrical and syntactic parameters describing the network and the land use patterns we find in them. Are they found?

We should begin by clarifying the syntax theory of this process and then looking for detailed evidence that it is the case. As with any other land use theory, the syntactic theory of the distribution of land use patterns sets off from the notion that land uses differ in their need to be close to or remote from movement, in that retail has more need for movement than, say, residence does. The difference is that the syntactic theory tries to articulate this in terms of the micro and macro properties of the street network. Centres of all scales in cities are for the most part made up of movement sensitive land uses, such as retail and catering, and to it is reasonable to expect that initial decisions to locate retail will be to go where there is more rather than less movement, and this, in the syntactic theory, is in the first instance a function of the network structure. Syntactic properties which generate movement then, will have more potential to attract movement sensitive land uses than those that do not. This should lead to pervasive relations between the syntactic properties of streets and their land use performance.

However, retail can also locate advantageously where it is close to theoriginal generators of movement - the buildings from which all movers depart and to which they return - and that means residences. This invokes another dimension of the syntax theory: the effect on distances (however we defines them) of different ways of aggregating and grouping buildings. We know from theory that distance from all point to all others in a space network linking blocks of buildings, as well as distance from some parts of the network to all others, will be minimised, other things being equal, where blocks are smaller in the centre and larger at the periphery than if they are uniformly distributed (Hillier 1999, Hillier 2001, 2003). If we put these two ideas together, we find that a generalisation of the corner shop seems to be the universal generator of retail concentration. We find retail developing, for example, at syntactically strong intersections, but also in local streets with the smaller scale grids - and so with a higher corner density - since that increases accessibility to more residences. Small centres develop under either set of conditions, strong centres usually require both, often increasing grid intensification by reducing block size to improve inter-accessibility as the centre develops. The larger scale aspects of this process

Table 1:

area	n-segments	%residential	%retail	Retail-residence ratio	segment-line-ratio	sl-ratio resid	sl-ratio retail	Diff factor
barnsbury	116	84	4.3	.051	.296	.302	.057	.188
Calthorpe	63	44	22	.500	.267	.300	.153	.510
South Ken	87	47	9.2	.195	.285	.299	.096	.321
Brompton	90	72	21	.297	.303	.346	.183	.529
mean		62	14	.274	.288	.316	.122	.387

Table 2:

	seg/line ratio	conn	cv	int-3	int-5	int-7	int-9	int-n
residential	.313	8.208	1.75	3.477	2.303	1.869	1.605	.972
retail	.145	15.88	3.37	4.642	2.669	2.097	1.764	1.064

work largely on the topo-geometric properties of the networks, since that is what shapes movement at the larger scale, while the smallest scale aspects of the process, such as the location of small groups of shops, the changes in internal structure as centres grow, or the decay of retail with metric distance away from intersections, work on a metric basis.

If this is the case, then we should routinely find differences in the syntactic and metric properties of retail and non-retail locations in the street network. We should find, for example, that although retail will sometimes develop on longer street segments, for example, at major intersections, we should in general find that on average line segments with retail concentrations should be shorter than, say, purely residential lines. We should also expect that although shorter, retail segments will tend to lie on longer lines, since line length will often (though not always) be associated with the stronger syntactic properties that we expect to find on retail lines.

In the movement study of four London areas reported in Hillier & Iida 2005 at this Symposium, we took all lines on which retail was predominant, and divided their length into that of the line of which the segment lay. We then did the same with residence only segments. Since the theory predicts that retail segments will both be shorter and lie on longer lines than residential segments, and therefore the *ratio of segment to line length* will be significantly larger. This is what we find.

In each area, we find that the ratio of segment to line length for retail segments is greater by a factor of between 2 and 5 than residential segments, as in Table 1. We also find that retail segments lie on lines with a mean connectivity nearly twice that of residential lines, and that at all radii retail lines are significantly more integrated than residential, and have significantly higher choice (betweenness centrality) values, as in Table 2.

In another recent study reported at this Symposium (Ji Zhang 2005), Zhang scaled all retail segments on a scale of 1-5 according to their proportion of retail, with 1 meaning all retail and 5 residential only. She then plotted a range of mean spatial values against the proportion of retail. She found, for example, that mean line length decreases linearly with a decreasing proportion of retail (r^2 .997), and that the proportion of retail increases linearly with the movement generating spatial variables including both the metric and angular versions of choice, and with angular integration.

& Iida 2005, we shows how cognitive information can be derived from the pattern of aggregate movement flows in the city, and in doing so shows unequivocally that the concept of distance that people are using in navigating cities is, while plausibly metric at the most localised levels (at which we can competently judge distances), above a certain threshold it is primarily geometric and topological, and formed by a mixture of the angular and connectivity properties of space. This has been hinted at for decades in cognitive science, but this has made little impression on debates within the social $physics_1$ community, who still regard a metric concept of distance as self-evident and necessary at all levels. (Ratti 2004) A least angle (geometrical), or fewest turns (topological) measure of distance is no less well-defined mathematically than metric distance, but is also phenomenological in that it relates to how human beings read and function in complex patterns space. We now know that it is also much more powerful in accounting for movement precisely because it is phenomenological in this sense. The concept of metric distance is then, although one of the two foundations of urban social $physics_1$, not optimal for urban systems research insofar as that research is looking at the relation between the physical structure and human functionality. Human beings just don't work that way.

Neither of the two foundational ideas of social $phsyics_1$, attraction and metric distance, then turns out to be quite as foundational for how cities actually work as has been supposed. We can also reasonable add that on the basis of present evidence, network structure and network agency, the twin pillars of network science, also seem to be the critical to city form and city dynamics, and neither is in the foundations of urban social $physics_1$. Of course, it can be argued that the interaction-location paradigm is in a sense about networks, But as we saw in the Rihll-Wilson study this was not fully the case. We might suggest that, on reflection, the place of the network in 'inter-action-location' theories is taken by the behavioural assumptions that link human economic behaviour to space, and in general this has taken the form of the distance minimisation that provided the basic link between human behaviour and spatial emergence.

It would seem to follow, then, that for urban social $physics_1$, the shift to network is not a methodological addition but a paradigm change. The presence of some concept of network in the model is not the question. What is in question is its agency. If the network is a fundamental factor in generating patterns of settlements, as commonsense and powerful evidence suggests, then it is not theoretically meaningful to have a neutral network. But if the network is allowed agency, then the nature of the model changes, since it now occupies the place previously taken by the distance minimising assumptions in providing the fundamental linkages between behaviour and space.

Eventually, the paradigm is in the maths, and the question is which equations are fundamental to how the urban system works and how. What are the roles do the network equations and the attraction equations, and how do they relate? The syntax view is that the fundamental processes are network processes, on which metric processes act as constraints. We argue that two things show that the network must be primary. The first is that in Hillier and Iida 2005 we not only show that real human movement is shaped by the topo-geometric structure of the network rather than by its metric properties, but also that these effects are built on top of a more fundamental and mathematically probable relation between the structure of a network and movement within in. This suggests that with further progress, and further refinement of models, human movement will become much more predictable than it is now. The second is the clear evidence that attraction is in the first instance generated by configuration, and so cannot be primitive. But one thing is clear. The answer to this question should give us a much deeper and more precise

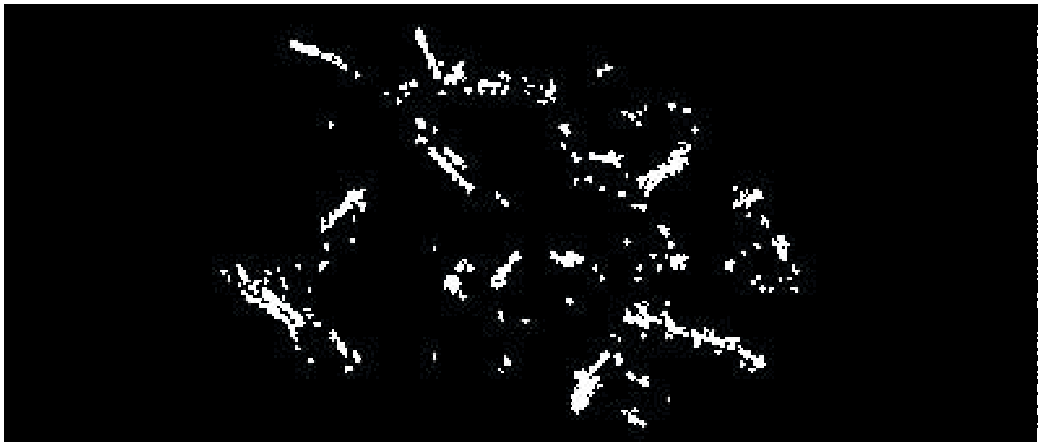

Figure 2:

model. This does not mean, of course, that it cannot be used in a 'pivotal' model (to use Andrew Smith's excellent expression) to simulate the transitions of the system from one state to the next as planned interventions and market force modify the system. But in a theoretical model which aims to give an account of how the city comes to be as it is, and so a more basic account of its dynamics, the pattern of differential attraction must surely be accounted for.

9. Space as distance

What then about the second foundational idea of urban social $physics_1$: that of space as distance? As Seaman points out, the space syntax definition of space is phenomenological: it is defined in terms of how space appears and is experienced by human subjects. At the same time it is geometrical, and the case the line structure is it objective at the emergent level. Although Batty's observation that there can be no unique convex breakup of space is perfectly correct - in fact this was obvious from the beginning since no convex break up of a regular grid can be made using the 'fatness' criterion defined in The Social Logic of Space - it seems that there is a unique least line map, given agreement as to what is to be mapped and what level of surface articulation is to be defined.

Since least line maps are also now known to have a fractal structure (Carvalho & Penn 2004), the axial map seems after all to be an interesting object. It is both locally phenomenological and globally well-formed, in that it can be derived from a system of rules, either in the form of a practical procedure for correcting draft maps (Hillier 2004) or as an algorithm (Turner, Hillier & Penn 2005). Those who have worked with axial maps know this is why they deliver so many results. They give a formal picture of the large scale emergent structure of the city is terms which link directly to the human experience of the city, and through this to the functional patterns of movement and land use which constantly evolve and change as the city does. The phenomenological representation of space turns out to be key link between the micro and macro functional dynamics of the city, and it is because it is both phenomenological and geometrical that this is the case.

We now also that the concept of distance also needs to be phenomenological. In Hillier

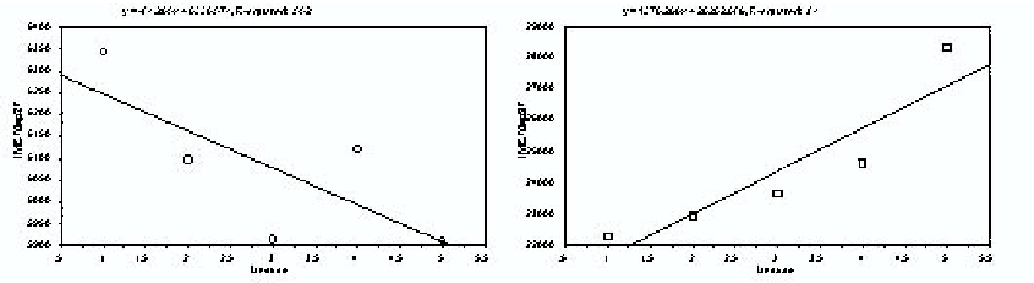

Figure 1:

Using the data from this study, we also tested the 'grid intensification' hypothesis by taking one of the areas and measuring the total length of street lines that lie within a certain radius, and looked at the effect of increasing radius. We found that up to a radius of about 30, we find that higher retail is associated with higher total (though not mean) depth (left below) , but that by radius 60 this reverses itself (right below):

Practically, this means that retail segments have more street length in their close neighbourhood that other segments. This is powerful evidence for the *grid intensification* effect argued in Hillier 1999 by which retail is often initiated in locations where blocks are small, since this means greater metric integration into the local neighbourhood. But as the radius of the total depth calculation in increased to cover the larger scale of the grid surrounding each segment, then the local grid intensification effect is masked by the much greater quantities of street length at higher radii, and so the measure increasingly expresses relative metric segregation of residence in the larger scale grid - hence the reversal effect. This is perhaps the clearest evidence to date that the metric properties of the grid operate at a relatively localised level. Conjecturally, we might argue that metric factors in urban grid work up to the scale at which we are able to make reasonable intuitive judgements about distance. At the higher level, we become dependent on geometric and topological intuitions since these are more easily recalled as images and composed into an approximate whole in which metric dimensions have lost accuracy.

Evidence of the powerful relation between land use patterns and the configuration of the urban street network are now routinely found in syntactic studies, so much so that they can be routinely used as part of the urban background in studies such as the study of crime in urban street networks also reported at this Symposium (Hillier & Shabaz 2005). What then of the interaction-location process? It seems again to play the role of acting as the background constraints on the configurational process which acts as the primary generators.

If we take the distribution of shops in North West Camden, as reported in Hillier 1999 (and due to Gebauer-Munoz) - see Figure 1 - we find that the patterns which were shown to be powerfully related to configurational variable, also display a geometrical in their spacing and scaling, suggesting that while the location of different densities of shops is generated by the potentialities of locations in the street network, it is also shaped by distancing and scaling constraints of the kind found in the interaction-location paradigm.

If this is so, then a way must be found to show the two processes working in a synthetic way. But it also shows that one of the two foundational ideas of urban social $physics_1$, namely the idea of attraction, should not be treated as a primitive variable in a theoretical

understanding of cities than we have ever had, and one that can inform the design and planning of cities at a new level.

10. Discussion

Space syntax can then claim to have shown two things which theoretically challenge the interaction-location paradigm: that to understand how cities work as socio-physical systems, at the micro as well as the macro level, phenomenological definitions of space and distance are required, that is definitions which mirror how human actors understand space and respond to its complex patterns as found in cities; and that the pattern of differential attraction that is found in all cities, and which defines their essential nature as networks of centres and sub-centres at all scales interwoven into a background of primarily residential space, arises in the first instance from the configuration of the space network emergent from the accumulation of built forms, though the dual process that creates the central and residential partitioning of the network.

These all challenge the twin paradigmatic foundations of the urban modelling tradition based on the newtonian paradigm of attraction and metric distance, which are also challenged by network science with is focus on emergent network structure as an agent in dynamic behaviour. The interaction-location paradigm is certainly part of the conceptual apparatus that we need to understand cities, but it seems likely that it should be part of a dual system in which network emergence and agency shapes events within a constraining framework defined by interaction-location.

Unfortunately, in the case of cities, the notion of network agency runs up against a further stumbling block: that applied to space networks agency looks like spatial determinism. It is. But it should not surprise anyone familiar with modern science. Spatial agency is one of the foundations of relativistic physics. Relativity proposes that space, while being invariant in something like the Newtonian sense of absolute space, acquires structure through the presence of masses distributed within it. This is often confused with the Leibnizian idea of 'relative space' but it should not be. Leibniz's argument was that space did not exist in itself, but was an illusion arising form the distribution of objects in space, just as he saw time as an illusion from the succession of events. In Einstein's theory space both exists and is lawful and invariant, but acquires both structure and agency through the distribution of masses. It is vital to relativity theory that it is not the masses that 'cause' gravity, but the distortion of space. In this sense physic events are shaped by space, because space is no longer uniform.

In fact, space syntax proposes an analogous set-up for human space. The placing of buildings in space creates, thought the operation of simple mathematical laws, emergent structure in the pattern of space created by those buildings. This then, in and of itself, and not the buildings, shapes the patterns of movement according to equally simple laws (as set out in Hillier & Iida 2005). In this sense, space not only has agency.In the last analysis it 'causes' the city to come into existence in the form its does and to function in the way it does. So syntactic space, while not Newtonian, is firmly within the field of possibility defined by mathematical phsyics.

In yet another sense the syntax theory is more newtonian than the netwtonians. If any one idea can be argued to be the foundation of the newtonian synthesis which brought modern science into existence, it is the principle of inertia. Prior to Newton and his predecessors, notably Galileo and Descartes, movement was seen in contradistinction to

rest. Rest was the state of nature and could therefore be assumed, but movement had to be caused by something, and so had to be explained. Through the principle of inertia - that a body would continue moving in a straight line forever - Newton showed that movement could be put on a par with rest, and so could be assumed. It was not having to explain the causes of movement that allowed Newton to show geometrically how movement was shaped by masses, and this is why, as Leibniz constantly complained, his theory looked to his contemporaries more like a mathematical theory than a physical theory.

The theory of natural movement - that is the proportion of movement flows that are due to the structure of space rather than the attraction or generation of particular origins and destinations - is in this sense an inertial theory of movement. It does not seek to explain how movement is caused. It assumes it, and shows how it is shaped by the structure of space. In this sense it could be argued to be a more properly Newtonian view of movement than one derived simply from the gravity equations.

When set up this way, even within the Newtonian paradigm, 'natural movement', that is the shaping of movement through the agency of space, seems the natural and proper way of conceptualising movement. We can define what the outcome would be of a random pattern of movement, and we can therefore show how real movement is rendered non-random by the structure of space that emerges alongside the aggregation of buildings in the city, and is therefore constantly modified by that process. It seems to be, then, the kind of movement theory that would be expected in a science drawing its inspiration and paradigms from mathematical physics.

We might then finally ask if social physics perhaps in a transition from social $physics_1$, as exemplified by the interaction-location paradigm (Wilson 2000) and social $physics_2$, as exemplified in Batty's 'network geography' and his syntax papers. We suggest that this will only be the case if the paradigm issues are faced squarely. Urban social $physics_2$ cannot simply be a continuation of urban social $physics_1$ with added methodology. A broadening in the paradigmatic foundations are required it there is to be a shift to a network view. The interaction-location paradigm needs to become part of a wider theory, with less exclusively newtonian foundations.

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