A Bird's Eye View from the Ground

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Introduction

Space syntax is a theory and a method for describing spatial configuration and relating it to social patterns of activities, movement, behaviour and social meaning. Its significance is in the description of the ways in which we recognise the spatial in the social and the social in space. So, it offers a theory of spatial and social description which at the same time is a theory of spatial and social understanding.

This understanding has been generally related to global properties of an environment as a whole and to the aggregate human behaviour independently of directional paths or the sequence in which spaces are visited in buildings or urban spaces. However, an increasing number of recent studies have been addressing spatial description and movement from the point of view of local relations and individual human actions (Penn 2001, Conroy 2001). *The question that the new generation of research tries to answer is whether the emergent population level behaviour at the level of the city and its relation to global patterns is rooted to a generic human behaviour at the level of the individual and the ways in which he/she interacts with the environment.* Inherent in this shift is again a question of understanding which relates to the ways in which we derive global knowledge from information observed locally, and to human cognition.

It is this shift that we observe in Bill Hillier's papers to this symposium, 'The Knowledge that Shapes the City' and the 'Architectures of Seeing and Going'. How do we move from diachronic experiences to the synchronisation of information into a higher order picture? How do we reconcile two kinds of knowledge: one derived from local explorations and the other emerging from our global interpretations? How do we progress from egocentric knowledge to knowledge over and above a series of perceptions that is fundamentally allocentric in nature?

Bill's resolution to these questions is provided by the notion of *invariance of a ubiquitous and objective human subject*, in the first paper, and of the *invariance of the grid* in the second paper. The human subject imposes its cognitive apparatus at all points in space and time, and this explains how cities emerge and how we navigate in them. This generalised human subject derives the concept of the grid as a perceptual-conceptual

invariance and uses it as a model to interact with complex spatial patterns like urban environments.

Before discussing these resolutions we need to set them in a context. How did we arrive at this point and which are the ideas that led to their development? The scope of this response is to focus on a specific stream of ideas in space syntax research, outline certain themes and open questions for the discussion that will follow. This stream of ideas is related to the notion of invariance, its role at the local and global level of description and its impact on intelligibility. I wish to clarify that my observations will be suggestive as my role is to mediate the interface of Bill's paper with previous and recent developments, with the view to stimulate a conversation rather than produce an argument that is coherent and complete.

Description retrieval – The Social Logic of Space

Looking at the ways in which space syntax internalised understanding at the early stages Bill went back to the notion of *description retrieval* as presented in the Social Logic of Space (Hillier and Hanson 1984). Description retrieval is a process by which abstract laws are derived from real space-time events and are subsequently embedded into further actions. In the beady ring settlement it is possible to retrieve a description from a local rule that is recurrently applied governing the position of blocks, their relations to other blocks and to the open space. It was proposed that abstract laws and space-time events are in a 'sandwich' like relation establishing the primacy of reality over abstraction and of the phenotype over the genotype (reality 1 – description – reality 2).

The notion of description retrieval was a solution to problems involved with the origin of structure and its locus. The theoretical proposition was that abstract laws are not anterior to the real events but depend on their embodiment and re-embodiment to survive. This proposition answered the question of the origin of abstraction by removing it from the brain and placing it on the reality sandwich. It also involved implicitly the notion of invariance as in the chain of the morphogenetic events the same rule is recursively applied. If the mind reads structure because of its embodiment and re-embodiment in spatiotemporal reality, it follows that description retrieval is about grasping rules that remain invariant.

The Social Logic of Space also offered a categorisation of settlement forms according to certain kinds of morphogenetic rules. These were defined as different degrees of restriction in an otherwise random process. In its essence the morphogenetic study was an analysis of form that was bottom up. It concerned with the ways in which complex forms emerged from the individual actions of local components. In a way, it can be seen as analogous to the new direction of research which aims at developing a study of individual actions and compare its results to the aggregate of human movement. But the elementary formulae of the morphogenetic study did not give ways by which we can describe the emerging complex form of urban space and the form of a settlement as a whole.

However, the distinction between long and short descriptions presented in chapter six of the Social Logic of Space clarified the difference between settlement forms like the

beady ring and settlements like the Bororo village. The former had a short description, a rule that controlled only local spatial relations generating a large list of local spatial forms, or p-models. The latter had a long description that was similar to that of the local spatial relations. The phenotypical complexity of the beady ring settlement at the global level was an outcome of a short genotype, whereas the phenotypical simplicity of the Bororo village was a result of a much longer genotype and of global rules of combination.

The implication then seems to be that the more global rules the elements of a system have to obey the more similar they appear and the simpler it is to comprehend the arrangement as a whole. In contrast, the fewer the rules the more the emergent form resembles what was called a 'polyfocal' net, which means that the system lacks any kind of focal point or recognisable overall shape.

In his first paper in this conference Bill provided a distinction between the morphogenetic rule governing a street pattern and the global form arising out of the process. 'The upper level synchronised description is retrievable because there is a convex global space to which all small objects relate'. We may add that the rule that generates the street form and subsequently the urban grid requires not only the blocks to join face-wise but also their open spaces to do so producing a global convex space. Going back to the idea of the long and short genotype and to the notion of the global as opposed to a local rule, the regular linear grid has more restrictions than the one that generates a labyrinthine settlement, and a global rule requiring linearization. In other words, in the events that generate the street more properties stay invariant than those that produce the labyrinthine arrangement, one of which is a global scale property.

Morphogenetically speaking the ideal grid is less economic than the labyrinthine grid in that it requires more rules to be followed. Perceptually and conceptually speaking it has enormous economy. The global form can be considered in itself rather than the individual elements. The inverse relationship between the economy in description and the economy in grasping the whole is because in the regular grid a large number of elements retain a global property invariant. In this way they appear visually similar and so it becomes easier to organise them in our mind in an overall pattern.

In an analysis of elementary shapes we conducted using syntactic properties of their perimeter we saw that the homogenisation resulting from a concentration of average connectivity values of perimeter locations at the top or the bottom range of the scale corresponds to the ways in which we perceive these shapes: the one on the left approximating the convex nature of a square shape, the one on the right as an L arrangement, where linearity prevails over convexity (Psarra and Grajweski 2001). The ways in which we understand configurations seem thus to be affected by a large amount of invariance in the properties of their perimeter isovists.

Spatial integration, intelligibility and synergy

The question of how to deal with the global physical structure of the beady ring settlement without losing sight of its local structure generated the representational

problem. This was addressed through axial lines and convex spaces. Each method of representation captured what Bill calls 'extrinsic' or 'all-to-all' invariance, one corresponding to the co-presence of points in the two dimensional extension of space, and the other with their co-presence in the linear spatial extension. The measure of integration accounted for the structure of the system as a whole from the point of view of nodal distances of each element from every other element. Spatial description linked invariant properties that are locally observed with global properties that can become understood only through movement.

A further step in relating local scale factors with the global scale structure was provided by the notion of intelligibility seen as a correlation between connectivity and integration. The correlation between local and global integration, or the synergy of the system, enabled a study of the ways in which different scales of the urban system relate to each other. It also identified the ways in which understanding of a local area informs us about our position in the context of the city as a whole.

Intelligibility defined as the relationship between parts and wholes was founded thus on a linear relationship between local and global measures, a relationship that remains consistent for the largest part of an urban environment. Inherent in a good correlation between these measures is thus the idea that as we move in cities the transformation of the information which we receive diachronically retains the relationship between connectivity and integration and between local and global integration invariant. Does this contribute to conceptual synchronisation? I would say it does but the correlation is a tool that looks at the invariance of the relationship between the parts and the whole in an all at once mode, or a top-down way.

There is one more important dimension of invariance I want to discuss before moving to the ideas involved in subsequent generations of research. Other things being equal in all to all routes in an urban settlement the integrated nodes carry the highest 'movement potential' and will tend to be crossed by movement more than any other elements in the system (Hillier 1999, The Hidden Geometry of Deformed Grids). An all at once view into tracking of visitor paths in buildings and urban areas shows a concentration of routes on the integration core. This suggests that integrated spaces or segments of integrated spaces are what all paths of observed movement have in common. With reference to museums, navigation is close to what Peponis has defined as a directed search where people set out to move to destinations but often deviate from the routes as they browse into the layout (Peponis 2001). The elements that remain invariant in all these quasi-directional, quasi-exploratory paths are the integrated elements. We are thus dealing with a movement invariance related to the total sum of routes in a layout.

It is reasonable then to say that we pick up local integration as a topological invariance in the sense that through experience we get to know that all our routes from the locally integrated elements to all other elements in an area involve only three changes in direction or that our simplest routes in the area pass from the local integrators.

Finally, space syntax research shows that the relationship between local and global measures and that between integration and movement flows are also correlated indicating that a fundamental relationship exists between local and global factors, intelligibility and the ways in which people move (Penn 2001).

Other branches of inquiry

But while identifying consistencies at the level of the whole system and at the level of the aggregate human behaviour, a number of branches of inquiry emerged that moved in the opposite direction: i.e. bottom-up. The predominant questions that arose were:

1. How can we describe and represent configurational invariance at the local level so that finer local properties can be captured beyond the individual axial line and convex space. How can we account for shape properties that can bridge the gap between the changing nature of our experience of the environment and the constant nature of its shape? Fundamental in these developments has been the distinction between order and structure proposed by Julienne Hanson (1989). The former accounted for geometrical order found in the plans of ideal towns that can be visually grasped at once, while the latter for non-geometric structures identified by space syntax analysis and learned by experience.

An analysis of shapes as layered tessellations by Bill led to the incorporation of geometric notions like metric distance, area-perimeter ratios and symmetries into the configurational analysis (Hillier 1996). Research at the Bartlett and at Georgia Tech developed notions like overlapping convex spaces and e-spaces mapping areas of information invariance and change in a layout like surfaces, shape edges and corners (Peponis et al 1997). Finally, the methodological question of how to represent the visual properties of environments at a fine level of detail with descriptive economy so as to overcome the methodological problem of the infinite isovist list (Benedict 1979), the isovist defining another local tool, led to the development of Visibility Graph Analysis (Turner and Penn 1999).

2. Another branch of research raised the question: how do people navigate in layouts? Studies in navigation in virtual environments (Conroy 2001) and research using agent simulation techniques (Penn 2001) showed that people tend to conserve linear or straight routes. So, starting from the local level behaviour of the individual we arrive at what stays invariant at the transformation of visual fields along a linear convex strip: the line. Following Gibson's idea that we observe invariants across views changing with motion a question that arises is: do people tend to conserve linearity because of the invariance of the line? Is it because they follow what structures their changing views? The implication of Gibson's notion of invariance under motion is that spatial cognition is not based on an accumulation of a series of images on the retina across time. Visual information is already structured *suggesting that what we are grasping is invariant patterns and perhaps, according to information theory, we are actively seeking redundancy and structure as we receive information* (Gombrich 1989).

3. We now arrive at the third line of inquiry as presented by Bill through his papers in this symposium. How a locally observed divergence in metric and visual accessibility factors are resolved to arrive at the notion of the grid?

Bill proposed that a fundamental property of urban systems that supports the role of the grid as a perceptual-conceptual invariance is the intersection of lines. This solves the reverse relationship between intrinsic metric integration and intrinsic visual integration as the intersection point is where the two measures are optimal.

Another important clarification concerns the distinction between a point based directional version of visual integration and the all to all points version of this measure. The former is defined as perceptual as it concerns co-visibility of points, whereas the latter as conceptual as is fundamentally structural. The perceptual version of visual integration is optimal when a long line intersects with a short one like in the L intersection. On the other hand, the all to all points visual integration is optimal at the X intersection.

The third proposition is that both types of intersections define the fundamental configurational units of the city. Cities are predominantly made of few long lines and many short ones with the L intersection occurring in outer areas, and the X intersection in the centre and in the local centres. The line length controls the information redundancy or the degree of structure observed at the local level, while the topological relations of line lengths define structure at the global level.

We have thus the proposition that two of the factors that constitute our urban experience at the local scale are similar to those that define urban structure at the global level: length of line and the pattern of intersections. However, in terms of the global structure there is a third factor: the topology of metric relations.

Two observations arise from this: First that through the two types of intersections we pick up invariants that operate across the local and global scale. What we perceptually group together at the local level structural class of elements belongs to higher order classes of elements that play a crucial role in the overall structure of the city.

Second, since the global structure is based on the topology of lengths the only way to grasp this structure is by positioning ourselves at different points into the system. This is because ringyness, a fundamental property of the grid, can be understood only by reaching the same location using alternative routes. Having reached the same point in different ways we can conceive different sequences that can lead us to the same location even if we have not acquired direct experience of these routes. This understanding is essentially allocentric as it requires the system to be seen or pictured in our mind from different locations. Research in the cognitive sciences seems to indicate that there is considerable support to this proposition. According to Barbara Tversky, although people experience the world from their own point of view taking other points of view is essential not only for social communication like understanding someone else's position, but also for a range of other cognitive functions like recognising an object and navigating in an environment.

However, in the acquisition of structure of real grids we seem to rely also on ideal grids. Bill's suggestion is that the ideal grid is a simplification and abstraction of topological allocentricity. This we project on the real grid in order to cope with the complexity of the latter which we cannot hold in our minds visually.

There are thus three ways in which order and structure interact in the ways in which we understand and negotiate the urban environment: intrinsically through the preservation of linearity and its properties of intersection, an invariant that groups the local scale information into the basic configurational unit in the formation of the city as a whole, extrinsically through the topological invariance of metric lengths and finally through a mental model, the ideal grid.

Traditionally the notion of ideal geometry in towns and cities as well as in architecture has been associated with the expression of symbolic meaning related with cosmic, social or political order. Robin Evans has explained that historically there was even a scientific effort to save the role of the circle in the universal order of things because of the social, religious, philosophical and aesthetic prejudice associated with perfect shapes (1995). The proposition that the ideal grid is a model for allocentricity and is used in the ways in which we read the environment shows that together with its symbolic strength geometry has another fundamental role to play: this is related to its capacity to provide abstract models for cognition and knowledge in general. We know that geometrically ordered towns are not as intelligible from the ground as organic cities are. However, Bill's proposition clarifies further the reason for which geometry has exercised a powerful attraction to architects, urban designers and city planners. Ideal grids served as models of what we human beings lack: a ubiquitous, and timeless or probably synchronic identity. Ideal geometry facilitates and expresses the idea of standing at one point in space and time while mentally occupying all possible points at once.

Where do we go from here?
The scope as said at the beginning is to open up a conversation at the end of this session instead of bringing things to a closure. So I will finish by a number of questions:

1. Having arrived at significant analytical observations about the divergent behaviours of metric and visual integration and at theoretical propositions related to the ways in which their resolution leads to conceptual synchronisation, can we explore ways in which description retrieval shifts up in scales gradually, picking up invariants of sequentially increasing global significance as we progress in a layout? If space is notion the conceptual dimensions of which can be measured and quantified can it be also considered as a notion that has also duration in time? Can we move from the line to the grid not in one step logic but through a study that takes into account a number of steps in the system?

2. The tool kit for representing space and shape has been sufficiently expanded, its latest stage of development being depth map. How do we use the most significant aspect of this

tool, i.e. the mapping of local and global scale properties at a fine level of detail to create a bridge between an all to all analysis and a point based directional analysis of a layout?

3. Should we distinguish between the process of understanding and the outcome of this process, i.e. knowledge of an environment? We know that the structure of information is in the environment and this is what we actually grasp, but the ways in which we reach there depends on processes and a processing apparatus that is in the brain. Similarly, is there a one to one correspondence between knowledge and behaviour, between the ways in which people understand spatial characteristics and their movement? What kind of help we can get from neurology and cognitive science to explore these questions?

4. Do navigation, wayfinding and cognition depend on purely spatial factors or they are also culturally determined? I refer to the example of a student of mine who visited Bilbao with the view to conduct a spatial analysis of the city. On her route from the centre to the waterfront she was surprised to find a continuous urban grid and a mixed used pattern instead of industrial wasteland she had expected to encounter. It seems she was projecting her experience of the relationship between Cardiff and its waterfront and from other northern European cities to a different place. How can a syntax of spatial cognition take into account the tacit knowledge of urban morphology and its social dimension people have, based on their cultural background and rules of convention?

5. And last but not least, how the choices taken during the generative processes of design interact with the descriptive models of the outcome of this process both at the aggregate level of properties and at the local scale description? Axes and lines are only but few of the elements that define the spatial formal vocabulary of architects and urban designers. Paradoxically, while space syntax has firmly established its contribution to the designs of the most distinguished architectural offices, the latest analytic developments based on tiny particles of space could not be more remote from design languages.

The early steps of space syntax came from purely formal analysis and experiments on how restrictions on a random process of aggregating cells could lead to well defined global patterns considered as genotypes rather than as phenotypes. The subsequent generations of research enabled the development of a theory and a method for the description of global properties of space and social relations. The latest generation tries to produce not only a much richer quantitative analysis based on both local and global factors but also to establish a link between the spatial properties of environments, our cognitive models and the patterns of our embodied experience. From the contributions to this conference I am certain that a large number of studies are at the frontline of the last generation of research. I am also certain that many people in this audience will come with more significant questions than the ones I have just raised.