SPACE SYNTAX
A Brief Introduction to
Its Logic and Analytical Techniques1

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ABSTRACT: The purpose of this article is to provide a background to the analytical
techniques and related terminology used commonly in space syntax studies. The
basic premises of space syntax are presented, its methodological procedures
described, and certain key terms defined. Finally, issues relating space syntax studies
to questions of spatial cognition are discussed.

THE SOCIAL LOGIC OF SPACE

Space syntax is best described as a research program that investigates the
relationship between human societies and space from the perspective of a
general theory of the structure of inhabited space in all its diverse forms:
buildings, settlements, cities, or even landscapes.

The point of departure for space syntax is that human societies use space
as a key and necessary resource in organizing themselves. In doing so, the
space of inhabitation is configured—a term that space syntax recognizes as
an act of turning the continuous space into a connected set of discrete units.
Converting the space to a discrete configuration is useful because different
labels can be applied to its individual parts; these parts then can be assigned to
different groups, people, or activities; different rules of behavior and
conventions can be associated with different parts of the space; and individual parts of space can be recognized as carrying a specific symbolic or cultural charge.

Such a view would typically imply that the configured space allows an existent social structure to be mapped onto itself; space syntax theory, however, denies this simple space-as-form and society-as-content distinction (Hillier & Hanson, 1984, p. 9). Rather, it is a central premise within the space syntax research program that social structure is inherently spatial and inversely that the configuration of inhabited space has a fundamentally social logic.

One important implication of this assertion is that the relationship between society and space is not merely that of mapping one domain onto the other but has a dynamic aspect as well; each modifies and restructures the other. One instance of this mutual modification can be seen in the activity of creating boundaries to configure space. The demarcation of boundaries allows particular relationships of access or visibility to emerge among the component spaces, and this in turn generates probabilistic patterns of movement and encounter within the population being housed. The effect is direct on both society and spatial configuration. Certain spatial components within the entire configuration will offer a higher rate of unplanned encounter between the members of the inhabitant society and others a comparatively higher degree of privacy. Similarly, giving selected members control of movement to and from particular spaces and limiting the freedom of movement of others vis-à-vis particular spaces creates levels of responsibilities, division of labor, and hierarchies of status that help maintain social organization with some degree of complexity.

The aim of space syntax research is to develop strategies of description for configured, inhabited spaces (of buildings, settlements, or built complexes) in such a way that their underlying social logic can be enunciated. This in turn can allow for secondary theories or often practical explanations to be developed regarding the effects of spatial configuration on various social or cultural variables (attributes). A related theme in space syntax research is to understand configured space itself, particularly its formative processes and its social meaning.

**GENERAL METHODOLOGICAL STRATEGIES**

The primary object of analysis within space syntax research, then, is the configured space—typically in the form of building floor plans or plans of urban fabric. In any analytical study of the configured space it is redescribed
in an abstracted format focusing on its topology. The premise underlying this abstractive procedure is that the sociologically relevant aspects of configured space can be captured at the level of topological description. From a purely theoretical point of view, this has largely been an accepted premise within space syntax literature, supported by common-sense observation rather than theoretical arguments, but methodologically there seem to be several points in favor of it. Topological descriptions are more robust with respect to documentation errors and so tend to be more reliable. They lend themselves very naturally to quantitative tools from applied discrete mathematics and to explanations that are in sympathy with the structuralist orientation of space syntax theory. Also, topological descriptions allow researchers a systematic way of disregarding small, circumstantial, and generally sociologically irrelevant geometrical differences between configured spaces, thus enabling several different spaces to be classified together under a broader typological category.

All this is best illustrated in an example. Consider, for instance, the plan of an office corridor (Figure 1). It is obvious that the relationship of the executive or manager (A) to his or her administrative assistant (X) will be asymmetrical with respect to the public corridor. In other words, X is directly accessible from P, whereas A is only accessible from P via X. On the other hand, the relationship of A and B is symmetrical with respect to P. If one were to represent each room with a node and direct access through any two rooms with a link connecting their respective nodes, one could then map the entire ensemble as a graph. Redrawing the graph as shown on the right, higher positions within the administrative hierarchy are mapped to upper levels and hierarchically lower positions to lower levels. Even the levels of relative privacy of the spaces can be mapped directly onto the levels of the graph.

The point in this relatively simple example is that a significant amount of socially relevant information about the body of people housed within this corridor is captured just by the graph without preserving such information as the relative sizes of rooms or the number of walls with windows in them. One may argue that such information is also socially relevant, but space syntax theory counters with the point that it is not essential. It is possible, even if unlikely, for instance, that the secretary may sit in a room that is larger than that of his or her boss or even that the boss may have a windowless office. But it would be an almost unworkable situation indeed to have the only access to a secretary’s room through his or her boss’s. The topological relationship of component units is much more essential as compared to other sociologically relevant spatial attributes.

Also, the matter can be taken beyond that of simply mapping existing social relationships onto the spatial structure. For instance, although the
deeper room of the manager reflects his or her higher position within the administrative hierarchy, it is also true that the secretary has a comparatively higher degree of control in practical terms. He or she can both control the access of others to the boss and also monitor the movements of the boss. If, however, the boss also has a separate access to his or her office as in Figure 1b, such a control can be appreciably weakened. Similarly, despite the privacy afforded to managers’ rooms in the plan in Figure 1a, the fact they only have access through the public corridor puts them, so to speak, at the mercy of a junior staff member patient enough or informed enough to find them arriving or leaving their offices. Once again, a separate access corridor in Figure 1b would weaken the relative control that can be attributed to the public corridor, although the administrative hierarchy on paper remains the same. A point to note here is the actual agency attributed to the spatial structure itself.

Spatial configuration, therefore, not only reproduces existing hierarchical relationships, but it also helps produce particular patterns of social relationships. More precisely, two attributes of spatial configuration seem to be...
relevant, both described through a single variable, called depth. Depth of one space from another can be directly measured by counting the intervening number of spaces between two spaces. One of the properties of the spatial configuration based on depth is asymmetry, mentioned earlier. As seen in Figure 2b, the greater the difference between the relative depths of two spaces with respect to a third (the public corridor here), the greater the hierarchical difference between them. A and B are hierarchically the same and hence on the same level (in a mutually symmetrical relationship), whereas A and X are hierarchically different and therefore on different levels (in a mutually asymmetrical relationship). On the other hand, the spaces that are hierarchically lower have a greater degree of control in this situation. The secretary’s room vis-à-vis the boss’s office and public corridor vis-à-vis the managers’ offices are both in a situation of stronger degree of control. As we have seen earlier, one way in which the effect of control can be countered is by creating circuits or rings. Opening of the second corridor as suggested earlier has the effect not just of reducing the effect of depth (by reducing the overall privacy of the managers’ rooms) but of creating alternative routes and therefore reducing the control exercised by the public corridor. Very generically then, the essential social effects of spatial configuration are determined by the mutual asymmetry of its constituent spaces and their distribution on rings and chains. Both these aspects of spatial configuration are adequately captured by the graph, and for this reason, the graph has been the key element of the space syntax spatial analysis. In recent years, Euclidean metrics have been introduced to the space syntax analytical methodology, but by and large, their role has been that of modifying the role of topology—fine-tuning it, so to speak—rather than inherently helping define spatial structure.

COMMON ANALYTICAL TECHNIQUES:
CONVEX AND AXIAL MAPS

Given the primacy of the graph, the main methodological issue in space syntax research has been the problem of reducing any configured space to an appropriate graph. The central problem here is that of the conversion of a continuous entity (the given spatial unit—the swatch of urban tissue or the floor of a building) into a discrete one. Where the configuration of space happens naturally through the making of deliberate boundaries (e.g., in buildings with clearly demarcated rooms), one simple and expedient technique is to let the partitioning follow these preset boundaries, producing a boundary partition.
Each node can be then assigned to a space label and the graph derived very easily from the building plan. But this apparently straightforward procedure has had limited success in capturing the necessary characteristics of the spatial structure. If the office plan discussed earlier had a slightly different geometry, so that the secretary’s desk was visually secluded from the entry to the boss’s office, this kind of partition would not be able to capture the working situation (Figure 2a). The accompanying graph shows the secretarial and managerial spaces as being mutually asymmetrical with respect to the corridor, giving the secretary some control of surveillance, whereas in practice, the secretary would have little control over potential access to the managerial space. This characteristic of the given spatial layout can be adequately captured with a different abstractive technique. Instead of the discrete units of space being identified with labeled spaces or rooms, the given layout can be partitioned into convex polygons. The graph of direct accessibility relations between the convex polygons captures the actual state of affairs more accurately: Both the secretarial desk and the manager’s room are now symmetrical with respect to the corridor.

This type of mapping of the given spatial configuration, called the *convex space partitioning* or simply the *convex map*, is among the most popular means of describing spatial configuration within applied space syntax studies, particularly for the analysis of building plans (Figure 3b). The procedure
to generate the convex map involves taking a given spatial setting and partitioning it into a set of “fewest and fattest” convex spaces (Hillier & Hanson, 1984, pp. 97-98). The actual procedure for generating the convex maps is iterative, starting with the identification of the fattest of the convex spaces and then progressively identifying the next largest one until the entire area is subdivided into a set of convex spaces. Based on this set, a graph can be constructed by identifying each convex space with a node and each accessible connection between the convex spaces with an edge. The convex map is arguably subjective, and terms such as fattest convex spaces remain intuitive rather than formally defined within space syntax literature. Although several alternative convex partitioning methods have been developed with more rigorous definitions and automated generative procedures, the practicality of the original manual technique still leaves it as a popular and effective means of generating a useful graphical representation of spatial configuration.

The efficacy of the convex map lies in its ability to capture the sociologically relevant relationships embedded within a plan. The picture that emerges, however, is static, describing what is in essence the mapping of discrete programmatic elements onto discretized elements of the entire spatial setting. As was discussed earlier, one of the concerns of space syntax studies has been to accurately describe the dynamism of social life in spaces—which means discussing not just a selective distribution of a population within a setting but also the range of options determining its mobility and the consequent creation of the potential for unplanned encounters. This is achieved through another discrete mapping overlaid on top of the convex map, seeking to capture structure of movement within a setting through the alignments of its constituent convex spaces. The map is called the linear map or the axial map.

The procedure is again described as an iterative sequence. The researcher lays down “the longest straight line” that passes through at least one permeable threshold between two adjacent convex spaces and repeats this until all the permeable thresholds between all adjacent convex spaces have been crossed. The resulting network of intersecting straight lines is the axial map (Figure 3c). As with the convex map, the axial map is also easily represented as a graph in which each line is represented by a node and each intersection as an edge.

The procedure for generating the axial map is also manual and inherently subjective, but its simplicity has made it an analytical method of choice for those space syntax researchers who focus on movement within spatial settings. The axial map was initially constructed to describe urban areas in which the structure of its street network could be described as a discrete spatial configuration. The underlying intuition is similar to that of convex spaces, based on the notions that first, the line of sight is a significant organizing and unifying device in experience and that second, the number of distinct
turns on a route are more crucial to spatial experience than actual distance covered. Perceived distance between two spaces, therefore, is counted through depth, namely, in terms of the number of turns along a path between one space and another rather than as actual journey length.

Figure 3:  
a. Proposed Ground Floor Plan, Eliat Residence, Mies van der Rohe, circa 1924; b. Convex Map and Corresponding Graph; c. Axial Map and Corresponding Graph

NOTE: The graphs illustrate the entirely different spatial structures described by the two techniques. The dark node in the convex map graph refers to the carrier (the outside space), and the other nodes are justified with respect to it; the graph of axial map is “justified” with respect to line 1. Note that to keep the graphs simple and readable, certain simplifications have been made to the convex maps; in particular, the convex spaces generated due to wall thickness have been ignored.
MEASURES AND DESCRIPTIVE CONCEPTS

The choice between using a convex map or an axial map for describing the spatial configuration of a given spatial setting depends on several factors; typically, if the analysis is used to discuss arrangement of programmatic spaces and generative types of buildings, convex map is commonly used, whereas if the focus of analysis is the understanding of behavioral characteristics of the spatial setting, axial maps are more useful. One significant reason for this is the discovery that a measure of syntactical asymmetry (related to mutual depth, see aforementioned discussion) called RRA (real relative asymmetry) or integration shows a tendency to correlate very strikingly with the distribution of population within an urban setting (Hillier, Penn, Hanson, Grajewski, & Xu, 1993).

The RRA, which is calculated for each space (i.e., for each convex space or each axial line and therefore for each node in the graph of the entire system), is a ratio. It is computed by calculating the average depth of each node from all other nodes in the graph. This mean depth is then used to compute a number called relative mean depth or relative asymmetry (RA), which is the mean depth expressed as a fraction of the maximum possible range of depth values for any node in a graph with the same number of nodes as the system. Because depth is always positive and the mean depth of any given node can by definition never exceed the maximum range of a node in the system, RA values range from 0 to 1. This relativization makes it possible to compare RA values of nodes from graphs with different number of nodes. RRA is a ratio of the RA values of the nodes of the given system and the RA values of the central node of a diamond graph with the same number of nodes as the system. The diamond graph is characterized by an almost normal distribution of nodes across its levels and so has been found to represent a more realistic benchmark for comparing spatial settings of different sizes. Current space syntax studies typically report integration values, which are the inverse of RRA values (1/RRA). Higher integration values of nodes, therefore, indicate that the node is less deep on an average from all other nodes, or in other words, that it is more integrated into the spatial system.

The empirical results mentioned earlier show a very noticeable correlation between integration values of a node, which represents a particular axial line, and the average number of people found on the space that is associated with the same axial line. This result has been reproduced in different cultural settings, at different scales, and in different types of environments and has often helped generate insights about urban structure (Min, 1993; Peponis, Hajinikoloaou, Livieratos, & Fatouros, 1989; Peponis, Ross, & Rashid, 1997; Read, 1999).
Several other numbers associated with the graphs—the number of its rings (its cyclomatic number) and the space-link ratio (or the ratio of its nodes to its edges)—as well as some derivative characteristics, such as the ordering of programmatic labels by the integration values of their representative nodes, have featured in space syntax studies and studies in architectural morphology. However, the areas in which space syntax research overlaps with that in spatial cognition has largely focused on the correlation between depth and population, or in other words, on the ability of space syntax techniques to predict the distribution of people within a given spatial environment; this is discussed further in the following section.

More recently, researchers have begun to give attention to the visual information that a given bounded and configured space allows a situated observer, and this has some obvious references to issues of spatial cognition as well. One way of describing such visual information is through the construction of visibility polygons, or isovists, from any given position within the configured space. The isovist of a position is simply the polygon created by delineating the area visible to an observer in that position, most often assumed as having a 360-degree field of vision. Several interesting properties of the isovists have been proposed by a number of different observers, which range from basic ones such as their area and degree of convexity to more exotic ones such as drift (which measures how eccentric the informational center of the isovist is in comparison to its actual center of gravity) (Benedict, 1979; Dalton, 2001; Turner, Doxa, O’Sullivan, & Penn, 2002). But on the whole, there is still a lack of an overarching theory that proposes a systematic social effect of the visual information available to a situated observer. In the absence of such a theory, the empirical work done on behavioral effects of isovists has not reported large successes despite displaying frequent technical innovation and methodological sophistication.

SPATIAL COGNITION AND SPACE SYNTAX

The observed relationship between behavior and spatial structure, and particularly the correlation between the degree of integration and number of occupants of a particular space, has led to a development of recent interest in spatial cognition among space syntax researchers. One of the key issues of relevance here is that of the intelligibility of a configured space, that is, the property of the space that allows a situated or immersed observer to understand it in such a way as to be able to find his or her way around in it. Space syntax has taken a unique approach to the concept of intelligibility of an
environment, defining it as the predictability of the global structure of an
environment from a reading of its local properties (Hillier, 1996; Hillier et al.,
1993). In operational terms, the global structure is predicted in terms of the
integration value (or RRA) of any component space; we have seen that inte-
gration represents the average depth of the spatial unit from all other spatial
units within a given system, and hence its value is affected by the entire spa-
tial configuration. One local property that is often used is called connectivity.
It is also defined for each spatial unit and is the number of spatial units
directly connected to it (which is simply the number of convex spaces directly
accessible from a given convex space or the number of axial lines intersecting
an axial line). The degree of correlation between connectivity and integration
values can be used as a measure of the predictability built into the entire envi-
ronment and therefore of its intelligibility. Other descriptors of local proper-
ties, such as integration up to a small radius (i.e., the integration value of the
spatial unit when considered only part of a small local system that is limited
to all spatial units within a given depth from it), are often substituted for con-
nectivity, particularly in studies of urban areas (Hillier et al., 1993; Penn,
Hillier, Banister, & Xu, 1998).

Such a definition of intelligibility is simple but provocative. First, it pro-
duces some apparently counterintuitive consequences. It predicts that a small
town whose street network is arranged such that streets that have a high degree
of integration connect to more streets on an average, and those streets that are
globally segregated connect to fewer streets directly, will be an intelligible
town on the whole. In effect, therefore, an urban setting such as Manhattan
with a regular grid network should have a very low intelligibility, whereas a
more traditional market town, such as Mytilini in Greece (Peponis et al.,
1989), with its labyrinthine street network, should have a moderate to good
intelligibility. This prediction is counterintuitive only on the surface, how-
ever. Actual experience shows that although the grid structure such as that of
Manhattan appears very understandable via an overview such as one pro-
vided from a map, once inside the spatial setting itself, it is very difficult for a
participant to orient himself or herself unless there is secondary information
in the form of numbered streets. In comparison, a street in a market town will
usually provide prominent cues toward its position within the entire setting
even at the level of its connections with other streets. The effect is very pro-
nounced in actual experience in these towns, where short and even random
walks bring even a relatively disoriented visitor to the main streets.2

This experience has been a key source of debate on the relationship
between spatial cognition and space syntax. One belief is that this is simply a
statistical effect. An unfamiliar person wandering about randomly within an
intelligible street network will have a higher proportion of choices leading
him or her toward the more integrated areas (which by definition of intelligibility have higher connectivity). The other is that environments provide cognitive cues for both local and global properties of space so that environments in which the two correlate will “feel” intelligible. If this is the case, then the question to be asked is what kinds of cues an environment can provide apart from the simple sense of connections to a particular place. In either case, the issue has obvious implications for the general topic of wayfinding. The contribution of space syntax research to wayfinding has been to shift the parameters of the question by showing that key elements of a good wayfinding environment are structurally inherent to it (Haq & Zimring, 2001; Peponis, Zimring, & Choi, 1990).

Other questions related to cognition also come into play in space syntax research. The nature of entities such as convex spaces and axial lines is one critical issue and is addressed by Penn in this issue. Another theme of interest is the nature of virtual “space.” The analytical concept of space that underlies space syntax appears as applicable to virtual space as it is to physical space, and its tools may be useful to understand the socializing potentials of virtual environments on the Internet.

Space syntax, then, is of interest to areas such as spatial cognition fundamentally because of its attempt to construct a theory of the socially constructed built environment on the basis of which to address the relationship between society and space. It is interesting that despite this initial sociological stance, the methodology of space syntax research itself has driven it increasingly toward issues of cognition. This has happened because space syntax has always sought to examine the relationship between behavior and space by examining behavior not merely with respect to its local setting (in which the perceptual typically dominates) but with respect to the global setting in which it occurs, where the cognitive dimension of behavior comes into play by necessity. The theoretical challenge before it now, as researchers in the field are increasingly finding, is to adapt the already successful structural models of the environment to new models of human cognition.

NOTES

1. This article is only a brief introduction to some common analytic and descriptive techniques within the field and the thinking underlying it. A much more comprehensive survey of the field can be found in Peponis and Wineman (2002).
2. This is a somewhat simplified argument; in fact, very intelligible layouts typically combine such traditional structures with a few major thoroughfares that cut across it. For a more nuanced discussion, see Peponis, Hajinikoloaou, Livieratos, and Fatouros (1989).

REFERENCES


