Analytic method to re-examine the concept of architectural space

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> *We can know all those things about physical space which a man born blind might know through other people about the space of sight; but the kind of things which a man born blind could never know about the space of sight we also cannot know about physical space. We can know the properties of relations required to preserve the correspondence with sense-data, but we cannot know the nature of the terms between which the relations hold.*
>
> (Russell 1982:16)

Space is a widely used concept in the architectural discourse. Space is however a problematic thing. Can a research method contribute to our understanding of what it is? Does this understanding help us to develop our research and practice? The focus of this paper is to make explicit our concept of space and how the methods applied in this explanation in itself can affect our understanding and creative thinking of space.

Practising architects may, unanimously, claim that their real expertise is the skill to design space. However they have not reached consensus on the issue of definition of the concept of space. Thomas A. Markus finds irony in the architects' claim that they design space since he believes that

> most of their effort goes into designing the elements that *enclose* space, into shaping the physiognomy of the surfaces of those elements
>
> (Markus 1993:7)

But despite this, he states, space is of course created, but as a kind of by-product.

From this statement it would not be a fair inference to draw that the generation of functional and meaningful space, i.e. architectural space, is a contingent consequence which arises within a process that does not aim directly at creating this space. Architects' claim is not, in fact, fully unjustified. They really do design space. In practice, while they proceed with forming and arranging physical elements they think of spaces that would fulfil functions and bear or create meanings. Their practice in dealing with form is not accompanied with complete ignorance of spatial consequences. There must be *some kind of knowledge* about space, and of course about its functionality. In its tacit form this is a knowledge which is shared by all of us, by creators and users of space.

If we agree with Rudolf Arnheim who holds that "our conception of space is crucial to our understanding of architecture" (Granath 1991:54), and if we want to proceed in the discourse of space usefully we need to make this knowledge explicit. We need to explain *how* space can be known and

Fig. 1a

Fig. 1b

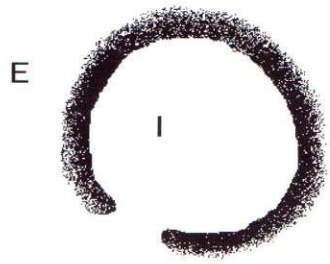


Fig. 1c

can be thought of. That is in fact "to try to characterise what is to be known in terms of how it can be known" (Hillier & Hanson 1984: 45). The essential question, which is the focus of this paper, is whether and how the methods applied in this explanation in itself can affect our understanding and creative thinking of space.

Is space a thing?

To take the first step in tackling with the problem of space we need to overcome the confusion about the *status* of space. How far can it be considered as a 'thing-in-itself' regarded "as an independent entity rather than simply as a by-product of, say, the arrangement of physical things" (Hillier 1996: 27)? We can try to describe this 'thing' with respect to the way it is built directly into social and cultural life.

Difficulties to describe space in its own terms seem to rise from its specific nature. Space is a vacancy and as such its bodily nature is obscure compared with physical objects. The way that common sense considers space can, of course, be questioned philosophically or scientifically but space, however can not be taken for granted in the way that we think we can take objects for granted (Hillier 1996: 26). This can constitute the main reason that space is rarely described in a fully independent way. This is even the case where space is of main interest, i.e. in architecture. Spatial enclosure is the commonest case in architecture where space is described "by reference to the physical form that define it rather than as a thing in itself" (ibid.).

The view that attributes logically prior and determinant status to objects in relation to space finds an extreme expression in Roger Scruton's suggestion. He argues that

> the idea of space is a category mistake made by pretentious architects, who have failed to understand that space is not a thing in itself, but merely the obverse side of the physical object, the vacancy left over by the building
>
> (Hillier 1996:28)

According to Bill Hillier this is a reflection of the deep influence of the Western philosophical tradition. Specifically, he points at the dominant view of space in western culture he loosely calls 'Galilean-Cartesian' view (ibid.). Here quantifiable extension of physical objects, considered as their primary and objective properties, is the basis for definition of space as generalised extension. Originally, the property of extension does not belong to space itself. It is attributed to space by the mediation of physical object that can occupy space. When the object is removed from its space it is reasoned that its extension remains in space, but of course, in abstract and non-objective form. So space is seen as the general, abstract framework of extension against which objects and events can be observed, a framework symbolised with a co-ordinate system.

This general view of space in western culture has not only influenced architectural scholars like Scruton. "All talk about space is error, he argues, because it can be reduced to talk about physical things." (Hillier 1993: 28). Space seen in this way becomes a neutral scene for what takes place in it. This view can not explain, for us, the real form of space. That is the form in which space is involved in social and cultural life which does not merely proceed in a neutral space since it has its spatially structured forms. The other thing that remains unexplained is how the space is constructed to not only accommodate events but also to generate them.

A conceptual model of space

Let us now examine some simple cases of 'spatial enclosure' and test whether talk of space really can be reduced to a

Fig. 2a

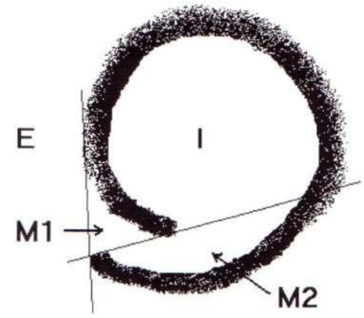


Fig. 2b

discussion about physical objects and, if not, in what kind of language can we talk about space that would allow its form to become clear.

For building a simple spatial enclosure let us suppose to use a formable object, consisting of a material like a mound of a mixture of clay and straw. This material, we believe of course, exists in reality and occupies a finite region of (the Cartesian) space. We suppose that the initial form of this material is a massive form that does not contain any empty space in itself, fig. 1a. We may begin the work by making a concavity in this pile, fig. 1b. Let us proceed by widening the concavity within the object while we make its peripheral mass thinner until it gets the thickness of a normal wall, fig. 1c. If we are inclined to hold the idea of determinant status of physical object, how would we describe what happens? We can say that the physical object (our working material) leaves empty the region of space it had initially occupied and instead, in its new form, occupies a region of space around this empty space. The result of all these events, an empty region of space surrounded by a specifically formed object, can be considered as a neutral space defined just in terms of physical object so long as it is not used as a real life spatial arrangement. If this happens the primary step would have also been taken in structuring the space through, first, differentiating between (categories of) spaces, and then linking these spaces into patterns. Space turns into a relational scheme. Spatial enclosure becomes associated with familiar categories of spaces; the *interior* space (the space within the boundary constituted by the physical object); the *exterior* space (the space containing the boundary and the empty space it contains). The descriptions between brackets are of course in terms of the view mentioned above. Since the interior space as a real life space is supposed to be used the boundary will be permeable. We can talk about another category of space, i.e. entrance space, though this space can be included in the interior space. To describe this space in terms of physical object we can say it is a piece of space left unoccupied between the two ends of the bifurcated form of the physical object that contains an empty space. This example is taken from Hillier & Hanson (1984: 73–76).

Let us see how we can talk about these spaces according to relations between them. The interior space (represented by I in fig 1c) is accessible from the exterior space (represented by E), and is fully visible from it. This description of space sounds trivial, though it is somehow independent from the physical object that has produced it. What is the benefit of this way of describing space? Let us leave this question until we have examined another spatial enclosure obtained by a minor change in the form of the first example.

Here we extend the boundary from one end following the course of an arc with a larger radius and get an enclosure with, roughly, a snail-like form, fig. 2a. Let us call this enclosure B, and the original one enclosure A. In enclosure B we can also distinguish interior space from the exterior. We can suppose the 'entrance line' as the open limit of the interior space and define it as a straight line when barred will isolate the largest obtainable interior space. In figure 2b the entrance line is the one which is drawn from the extended end of the boundary and is tangent with the surface of the boundary. The interior space is a continuous space but the line that connects the two end of the boundary and is obstructed by its inner surface divides the interior into three spaces with, relationally, characteristic properties. These spaces are distinctively definable in terms of relationship between themselves and between them and the exterior space.

These spaces comprise subclasses within the category of interior space. We represent the largest component of the interior space by I and the two smaller ones by M1 and M2 (associating them with a kind of mediating space) and the exterior space by E, fig. 2b. Now let us see how these spaces can be described in terms of their *relationality*. Each represented space has a relation of adjacency to all other spaces, but of course, not a relation of permeability from all of them. Space M1 is permeable from E and M2. We take also the relation of visibility into account to describe the properties of spaces, as we did in the first example. Space M1 is obviously visible from the exterior space. It is also visible from M2. By this we mean that, either if we move around in M2 we can see the whole body of M1, or there can be regions in M2 from which all regions in M1 are visible. Between M1 and I there is no relation of visibility. It means that there is no point in space I which can be seen from any point in M1 and vice versa. We can proceed and describe other interior spaces in the same way. M2 is permeable from I and M1, but not from E. It is visible from all other spaces including the exterior space. Consequently, all other spaces are also visible from this space. Finally, space I is only visible and permeable from M2.

The combination of these relations constitutes patterns that can clearly be displayed by a device called justified graph. In this kind of presentation the shape and size of the defined units of space are of no importance. The relations between them are in focus. A circle represents one space and a link between two circles represents some kind of relationship between spaces. For example to present a spatial pattern from the point of view of visual relationship we simply link those circles which represent spaces which are visible from each other, we can call this a visibility graph. Likewise you can represent the structure of possible movements in a permeability graph.

The justified graphs in figure 3 represent our two examples, A and B. For instance, figure 3c displays the spatial pattern of enclosure B concerning *permeability*. This is a sequential pattern in which space I is located at the deepest position, seen from the exterior space. The spatial pattern of enclosure B from the point of view of visual relationship is different, fig. 3d. The pattern is not sequential here. Space I has a shallower position from E, and the two spaces M1 and E are in a symmetric position in relation to the two other spaces. In

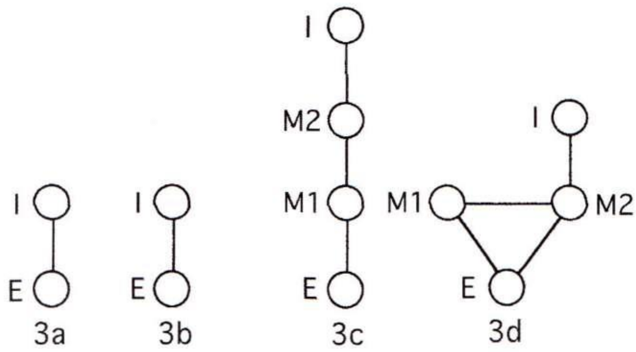


Fig. 3 Justified graph with the exterior space down (shallow) and the interior space at the top (deep).

enclosure A the spatial pattern from both points of views, visibility and permeability, are the same, fig. 3a & b. They are consequently less complicated compared with enclosure B.

Description of space as patterns of relations (or as configurations) is claimed to reveal the independent nature of space. But here the role of physical objects in relation to space has not been ignored. The point is that objects (walls) make spaces but space is not made of objects, neither the reverse side of objects. Space is made of *relations*. Relational property of space through which we make sense of it belong to space itself and not to the physical object that makes it. In the example of enclosure B the physical object, the boundary, has a continuous form, and because of this, its components are infinite. The space, instead, has finite and distinctive components with definite relations. It has a configuration of its own. The interesting thing is that the exact configuration can be obtained by the means of different forms of physical objects. A variety of these forms producing the same configuration as in example B are displayed in figure 4a & b.

The urinal – a spatial invention

One may ask whether this specific configuration (of space) has any concrete relevance in real life spatial arrangements. We would like to answer yes. This configuration has real functions. There are samples of this pattern in what we call vernacular architecture. But how this space was first designed. Nobody knows. But we may speculate. Consider our first example of spatial enclosure and its simple configura-

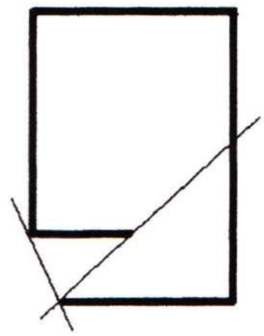


Fig. 4a

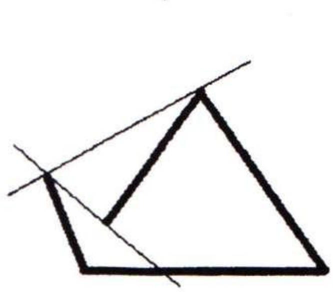


Fig. 4b

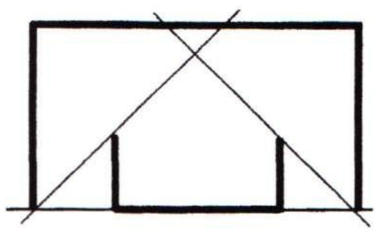


Fig. 4c

tion, fig. 1c. It forms associations with a primitive human shelter once built in the old ages. It does not seem that much work was needed to develop this space to a relatively more complicated configuration like the one we concern, fig. 2. Practically, as we saw, it sufficed to extend the boundary (the wall of the enclosure) a little bit from one end, and this should not have required any extra skill in working with material forms.

But the question is what could be the intention of extending the wall. What image did those people who carried out this extension have in mind? Was that an image of just another bit of a physical object, or the image could be a (spatial) configuration which would fulfil a specific demand. For example a demand for a, visually, protected space. If it was so we can suggest that the new enclosure was, in fact, a spatial invention rather than an elaboration of the form of a physical object.

In many villages in Afghanistan this pattern has been used for building latrines, outdoor lavatories. The material of the wall is clay and straw, and the roof is made of wood and straw mat and clay. From the point of view of available material and technique and, more importantly, from the point of view of the demanded space the building, which its tradition reaches primitive communities, seems to be the most economic and rational solution. We have been using the same spatial arrangement in our male urinals, to obscure but leave open, in times when we were not applying doors and advanced techniques, fig 4c.

For mankind, the social being, even to ease nature is not as easy as it is for animals. It demands its own, culturally determined, spatial form, and to fulfil this demand it requires spatial inventions.

Although spatial inventions, like the case we have examined, has something to do with the problem of visibility and human eyesight but what are invented are patterns of relations which are not easily visible. The very problem of relations is something that concerns the nature of our knowledge of physical space. This knowledge has not a simple relevance with our perception through sense data, and can never be reduced to them. Bertrand Russel already 1913 in his book *The Problems of Philosophy* stated that

> space as we see it is not the same as space as we get it by the sense of touch; it is only by experience in infancy that we learn how to touch things we see, or how to get a sight of the things we feel touching us.

And he proceeds:

> Assuming that there is physical space, and that it does thus correspond to private spaces, what can we know about it? We can know *only* what is required in order to secure the correspondence. That is to say, we can know nothing of what it is like in itself, but we can know the sort of arrangement of physical objects which results from their spatial relations.
>
> (Russel 1982: 14–15)

Russel suggests a clear distinction between physical spaces (independent from subjects) and private spaces (experienced

18	15	18
15	12	15
18	15	18

Fig. 5a. Total depth=144

36	29	24	21	20	21	24	29	36

Fig. 5b. Total depth=240

or conceived by individuals). He also suggests there is no way to explore the *essence* of physical space through experiences. Our knowledge about relations in physical space have nevertheless relevance to their independent reality. Just because of this it is a useful knowledge in our everyday life. The problem arises from the abstractness of relations and the way we understand them. This explains why one of the main matter that architects design, i.e. space (or void), generally belongs to the realm of tacit knowledge. The non-discursiveness of spatial patterns or layouts is a crucial problem in architectural research.

Properties of spatial configurations

Bill Hillier explores in his recent book, *Space is the Machine* (1996), the possibilities to:

> bring the elusive 'pattern aspect' of things in architecture and urban design into the light of day, and to give quantitative expression to the age-old idea that it is 'how things are put together' that matters.
>
> (Hillier 1996:1)

He has moved the concept of *configuration* to the centre stage.

> Configuration means, put simply, relations taking into account other relations.

And as he puts it:

> The configurational techniques developed for research can, in fact, just as easily be turned round and used to support experimentation and simulation in design. (ibid)

The book is an articulation of a "philosophy of design".

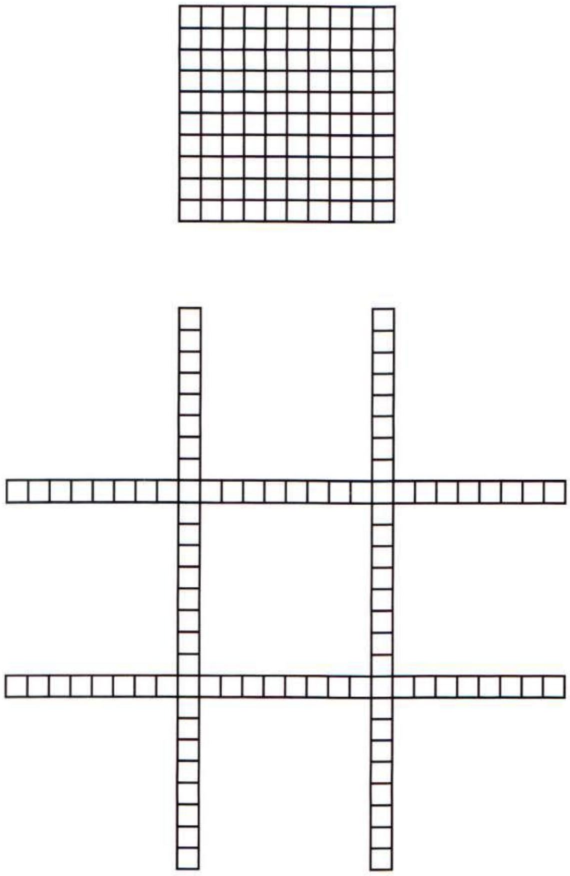


Fig. 6a & b. Total depth=26,000 and 144,336 respectively

Let us in his spirit take a further step in our exploration of architectural space. We will apply the same technique as in the previous section. We here count the syntactic steps from each space to all other spaces. It gives a measure called depth. Let us for instance compare the depth of two simple spaces consisting of nine units, one formed as a three by three "square" and the other as a one by nine , fig. 5. We find that the total depth of these are 144 and 240 respectively. If each unit represents one person the mean depth to all other persons is less in the square than in the street, i.e. 16 and 27.7 respectively. You can also calculate the perimeters of the two shapes, which are 12 and 20 respectively. These spatial properties are results from two different spatial forms, and we might intuitively understand its relation to function. The proximity is higher in a crowded square than in a crowded street. A long perimeter means a larger interface between customers and shops. A simple conclusion, which we all might agree upon, is that streets are better for shopping and squares for gathering.

Compare two systems consisting of 100 quadratic units each, fig. 6. One organised as a ten by ten square and the other as a regular grid pattern with a street width of one unit (think of them as 10m x 10m). The total depth of the square is 26,000 and of the street pattern 144,336, i.e. the latter gives a mean depth more than five times higher. We find similar result if we compare the facade length of the two urban layouts. They are 32 and 192 units respectively. These examples support our concept about how differently streets and squares function.

Let us test what happens if we compare different space configurations (or you might still call them different forms if you prefer). We return to the simple street analysis, the one by nine unit shape, fig. 5b. This time we twist one of the end units around the corner. Still the total depth is of course 240, fig. 7a. If we now move this unit one step towards the centre of the street we find astonishingly that the total depth is reduced. And what more, the depth of each space changes for each move, fig 7b&c&d. A shortcut conclusion of this is that each local change influences the global spatial system. To extend it further, a street addition or a street blocking effects the whole town, far down to every local space. This fact we might grasp intellectually, but most architects, quite contrary to this fact, seem to insist on that space (and place) is a local phenomenon. Likewise, a change in a plan layout of a building changes the spatial properties of all spaces of it, and also how a specific space relates to all the other ones.

Next, see the lines in figure 8a as streets. Suppose that buildings and inhabitants are evenly distributed along the streets. If you were asked to locate a shop by your client, where would you advise her to do it? Well, most likely by the horizontal line. Why? Simply because you imagine that more people have to pass through this street, which would make it a "high street". Suppose that this tiny town will flourish and more space is needed. As a planner you might suggest the authorities to add a new street parallel to the high street, fig. 8b. Where would you now propose your new client to locate her shop? There are two optional arguments. One is to locate adjacent to the previous shop, to compete. The other is to locate to the new street, as it from the spatial point of view is equal to the high street. This time the argument might be to conquer the new catchment area.

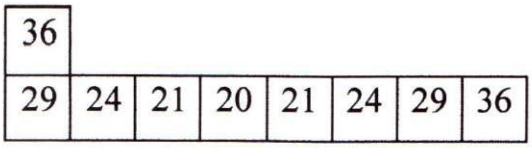


Fig. 7a. Total depth=240

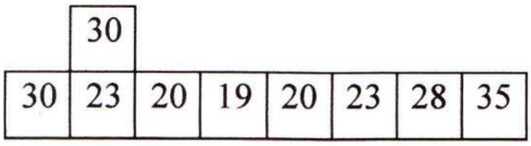


Fig. 7b. Total depth=228

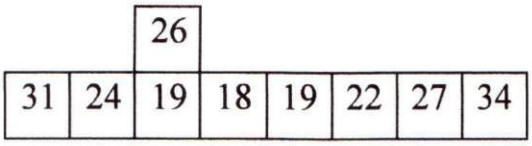


Fig. 7c. Total depth=220

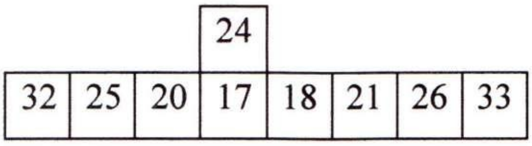


Fig. 7d. Total depth=216

Adding a few more streets to this new street would definitely turn this into a new high street, fig. 8c. This illustrates what space does – and we all know it. It is a matter of movement economy.

Today it is possible to explain and calculate the shape and effects of different configurations. What might be called natural movement is possible to predict. Depth, or a more elaborated measure called integration used in figure 8, is highly correlated to observed movement. Analytic methods may help us understand space – and to design better.

Camillo Sitte meets Space Syntax

The simple models presented in the previous sections has been quoted from and/or inspired by the methods and research developed by Hillier (1996), by Peponis et al. (1997, 1998), and by their colleagues. Let us now introduce a more elaborate discussion originally put forth by Camillo Sitte in 1894. He wrote:

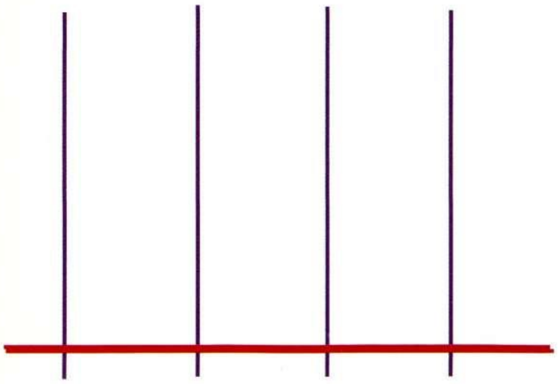


Fig. 8a

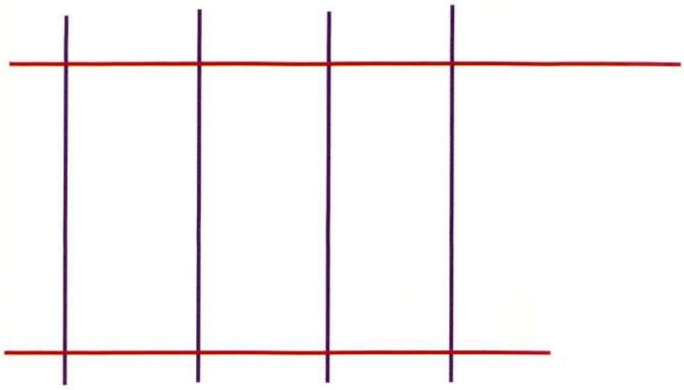


Fig. 8b

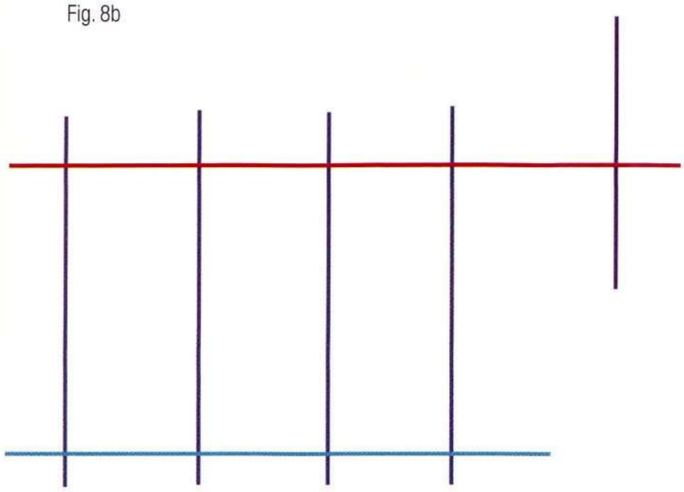


Fig. 8c

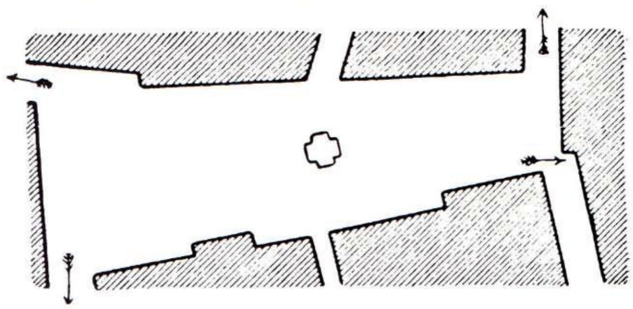


Fig. 9a. Neue Markt, Vienna (Sitte, fig. 105)

> It is significant that when children at play follow unhindered their own artistic instincts in drawing or modelling, what they create bears a resemblance to the unsophisticated art of primitive peoples. One notices something similar with regard to children's placing of their monuments. The parallel is to be seen in their winter pastime of building snowmen. These snowmen stand on the spots where, under other circumstances and following the old method, monuments or fountains might be expected to be located. How did this placement come about? Very simply. Imagine the open square of a small market town in the country, covered with deep snow and criss-crossed by several roads and paths that, shaped by the traffic, form the natural lines of communication. Between are left irregularly distributed patches untouched by traffic; on these stand our snowman, because the necessary clean snow was to be found only there. (Sitte 1965, pp.21–22)

We will now apply a specific Space Syntax technique called "all-line analysis" (see Hillier 1996: 130–132) to one of the examples discussed by Camillo Sitte in his book (:138). It is a square named Neue Markt in Vienna, fig. 9a. When we apply the software called Space-Box to the plan drawing, it will generate tangents between all convex corners. Integration values (a depth measure) of all lines are then calculated. The result is presented as red lines when they are integrated and as blue lines when they are segregated, fig. 9b. Here the main integrating lines cross along the square.

Let us then manipulate the square by omitting the fountain, fig. 9c. The integrating lines still have almost the same position and direction. The square maintains to a remarkable extent the same spatial structure with and without the fountain. According to Camillo Sitte this would not have been the result, because the fountain is blocking a line connecting two opposite lanes.

The red lines will generally be more used than the blue ones. The lines so generated may resemble the possible movement through "the snow". Let us see what happens if we follow what Sitte suggests and move the fountain a few metres away from its previous location to a less used space, fig 9d. Quite contrary to his theory the spatial structure (movement) is changed profoundly. Lines with high integration are dispersed in several directions.

Let us finally put a snowman in a location where most likely no inhabitant would have walked through the snow, fig 9e. Even this tiny object seems to have remarkable effects on the spatial structure. Children put their snowman by intuition, but they are not aware of the provisional effect of their intervention in space and they are perhaps allowed to put it there because of its provisional effects. The location of the fountain may also have been carried out by intuition but its spatial consequences were not unexpected. Here intuition is embedded in the cultural content and can not be explained simply by the example of intuition of the children.

Camillo Sitte introduced his challenging notice to support normative principles with artistic intentions. A new analytic method is able to give light to this century-old notice about human spatial behaviour.

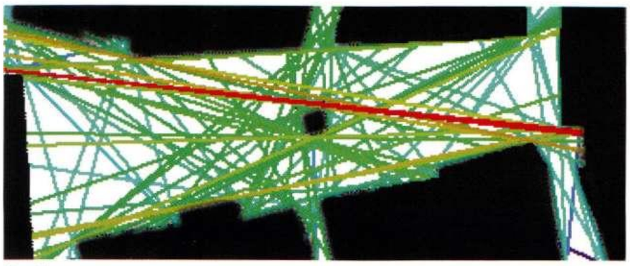


fig. 9b.

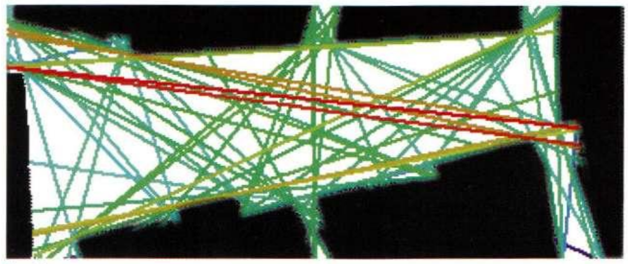


fig. 9c.

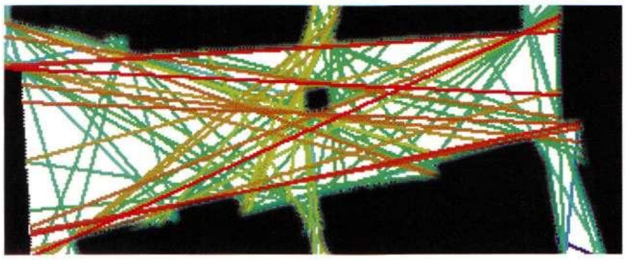


fig. 9d.

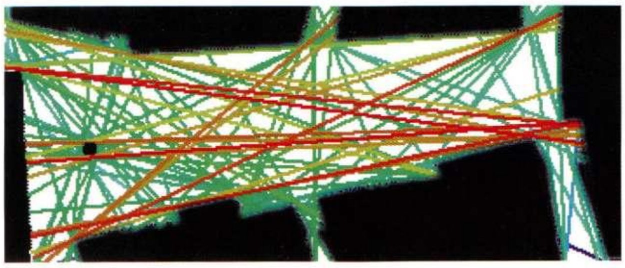


fig. 9e.

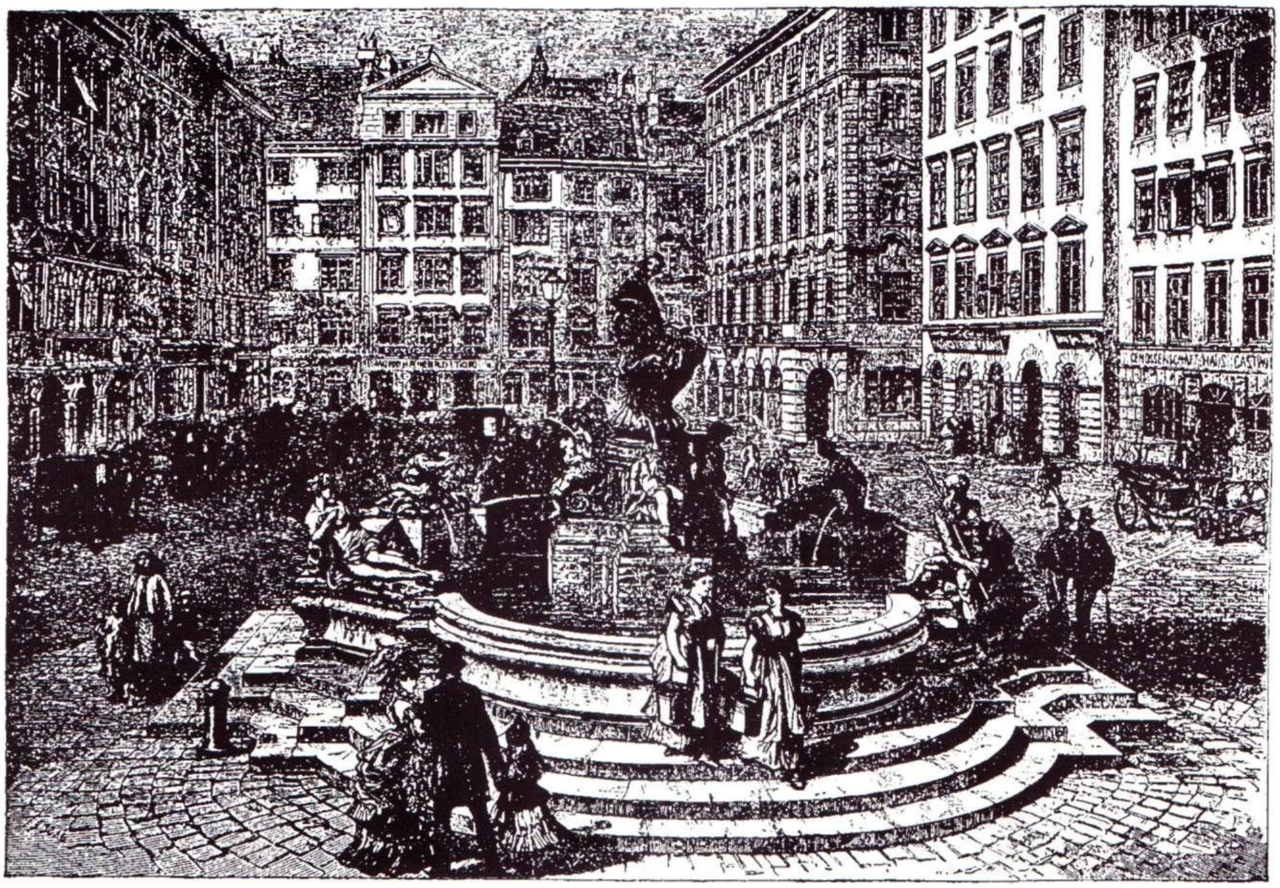
Scientific and experiential knowledge

A well-known architect, Norman Foster, has been working close to Bill Hillier and adopted Space Syntax Analysis in his designs. He claims that this method has suggested new approaches and solutions but first of all made it possible to test different designs. Foster said in his opening address to the first Space Syntax Symposium in London 1997 that

> it excites me to know, from the perspective of my own very demanding environment in architectural practice, that the techniques they (i.e. Hillier et al) have pioneered actually work

and he concludes:

> Creating connections, demonstrating them and enabling people to make them – these are the grammatical keys to urban planning. Space syntax's particular kind of analysis, for all that it is objective and scientific, answers the instinctual demand for orientation which I, as a lover of cities, care about passionately. (Foster 1997: xvii)



Neue Markt, Vienna (Sitte, fig. 29)

Foster claims that scientific theory and method support architectural design by explaining or question his intuitions. And, more important, makes him able to "convince a developer or a team of bureaucrats, far removed from that academic world." (:xvii)

Scientific theories are attempts to model phenomena in the world, no matter if we observe them and sense them immediately or if they are underlying principles which we are not able to grasp easily.

> In its purest form, a theory is a kind of abstract machine, since it is an attempt to create abstract representation of the working of processes which give rise to what we see.
>
> (Hillier 1996:75)

Architectural theories have to a great extent been predictive and speculative. Architects certainly need ideas that support their creative processes, which expand the realm of the possible. These theories have however generally been strong in the generative phases but weak in the predictive. Architects certainly also need theories of the latter kind to survive as a profession.

Space syntax theory has gained ground during the last decades within the scientific society. It has not only attracted architecture and planning scholars, but social scientists of different kinds. See for instance the proceedings from the international symposia on space syntax and the theme issue of this journal, 1993:2. Now it is time to go deeper into a discussion about how this theory relates not only to the experiential knowledge among architects but to other scientific theories that claim they are dealing with space. For instance, there are two contributions that explicitly discuss Space Syntax in relation to phenomenology. (Seamon 1994, Dovey 1999)

What Bertrand Russel states and what Bill Hillier and his colleagues have developed may be shocking for those who suffer the illusion that you can capture the essence of phenomena through immersion in the world and through immediate experiences. Space is not a simple and neutral thing. It is far from what Roger Scruton suggests. We want to open a discussion about the concepts of space that for instance Rob Krier (1979) and Christian Norberg-Schulz (1988) represent. An old text like the one by Camillo Sitte or the inaugural lecture by the internationally famous Swedish functionalist architect Gunnar Asplund (1931) might be more up-to-date than the modern ones.

Space contains it all

Bill Hillier and his colleagues have revealed, or rather made explicit, fundamental aspects of architecture and urban design. They have been able to make the non-discursiveness of space discursive and thereby made it possible to relate function to form. Hillier argues that space (the void) is the main matter that architects handle in their profession. He turns the traditional architectural discourse a bit upside down when he writes:

> The answer is simple, and will lead us into new theoretical territory. Space is not a structureless void. We only believe it is by using an implicit analogy with physical systems. What we call structure in a physical system, whether artificial or natural, has to be created by putting elements together in some way. Space is not like this. In its raw state, space already contains all spatial structures that could ever exist in that space. It is in this sense that space is the opposite of 'things'. Things only have their own properties. Space has all possible properties. When we intervene in a space by the placing of physical objects we do not create spatial structure, but eliminate it. To place an object in space means that certain lines of visibility and movement which were previously available are no longer available. (Hillier 1996:344–345)

Architects may perhaps know more about space than a man born blind. Though, when listening to and reading texts by architects and architectural scholars some doubts may emerge. We claim that space and its configurational properties must be explicitly incorporated into the architectural discourse and into architectural practice. Space is not a by-product of buildings or enclosures, not just scenic views from the exterior towards facades, not just the meaning and place. Architecture is too important to people not to be handled professionally – and scientifically.

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References

ASPLUND, GUNNAR (1931) "Vår arkitektoniska rumsuppfattning" in *Byggmästaren A*, Vol. 10:203–210.

AZIMZADEH, MIR (1999) *Society – a Spatial Configuration.* Dept of Urban Design & Planning, Chalmers, Göteborg. (diss, licentiate). See also *Nordic Journal of Architectural Research*, Vol. 11, No 4:131–146

DOVEY, KIM (1999) *Framing Places.* London.

FOSTER, NORMAN (1997) "Opening Address" in volume III of proceedings from the *First Space Syntax Symposium,* :xvii–xxii. London.

GRANATH, JAN ÅKE (1991) *Architecture, Technology and Human Factors.* Chalmers, Göteborg (diss).

HILLIER, BILL (1996) *Space is the Machine.* Cambridge.

HILLIER, BILL & JULIENNE HANSON (1984) *The Social Logic of Space.* Cambridge.

KRIER, ROB (1979) *Urban Space.* London. Orig. 1975

MARKUS, THOMAS A. (1993) "On re-discovering space – a critical editorial summary" in *Nordic Journal of Architectural Research*, Vol. 6, No 2:7-10.

NORBERGSCHULZ, CHRISTIAN (1988) *Architecture: Meaning and Place.* New York.

PEPONIS, JOHN (1997) "Geometries of Architectural Description: shape and spatial configuration" in volume II of proceedings from the *1st Space Syntax Symposium*, paper 34. London.

PEPONIS, JOHN et al. (1997) "On the description of shape and spatial configuration inside buildings: convex partitions and their local properties" in *Environment and Planning B*, vol. 24:761–781.

RUSSEL, BERTRAND (1982) *The Problem of Philosophy.* Oxford. Orig. 1913.

SEAMON, DAVID (1994) "The Life of the Place" in *Nordic Journal of Architectural Research*, Vol. 7, No 1:35–48.

SITTE, CAMILLO (1965) *City Planning according to Artistic Principles.* London. Orig. 1889.