Space syntax

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Abstract. This paper addresses itself to the question of how and why different societies produce different spatial orders through building forms and settlement patterns. It consists of three parts. Firstly, at a metatheoretical level, it is suggested that spatial organization should be seen as a member of a family of 'morphic languages' which are unlike both natural and mathematical languages but which borrow properties from each. In general, morphic languages are used to constitute rather than represent the social through their syntax (that is the systematic production of pattern). Secondly, a general syntactic theory of space organization is proposed. It is argued that spatial patterns in both complex buildings and settlements fall into eight major types, which are interrelated in structural ways. Finally, the syntactic theory is used to integrate a number of recent general propositions made in anthropology regarding human space organization.

1 Preliminaries: mathematics and the 'sciences of the artificial'

"We cannot understand the flux which constitutes our human experience unless we realise that it is raised above the futility of infinitude by various successive types of modes of emphasis which generate the active energy of a finite assemblage. The superstitious awe of infinitude has been the bane of philosophy. The infinite has no properties. All value is the gift of finitude which is the necessary condition for activity. Also, activity means the origination of patterns of assemblage, and mathematics is the study of pattern" (A N Whitehead, 1961).

Belief in a mathematical order inherent in nature has always been a fundamental postulate of theoretical science. First put forward by the school of Pythagoras, which developed a numerical theory of natural order from such discoveries as the relation between musical harmonies and numerical proportions, it was linked by Galileo to the experimental method, and together they form the dual foundation of the modern conception of science. Analytical geometry, calculus, group theory, non-Euclidean geometries and perhaps catastrophe theory were all subsequent steps in linking our conceptions of natural order with mathematics. However unreasonable a belief mathematical order in nature may appear in principle, the 'unreasonable effectiveness' of mathematics in the natural sciences leaves no doubt that it has been amply justified by events.

But the sciences of man-made entities like settlement patterns, societies, and languages, have no such record of success to confound the sceptic. Moreover, the claims of these sciences to be excused for their poor mathematical development on account of their extreme youth sounds more and more uneasy as decades pass. However, the root reason for the lack of mathematical theories in the 'sciences of the artificial' may be that they are not sought after, since the fundamental postulate justifying the intervention of mathematics in these sciences is not a belief in a mathematical order inherent in the objects of study, but simply a belief in the power of mathematics as an instrument. In principle such a reduced claim appears justified. Even if nature does work mathematically, this does not imply that man the artificer also does.

To believe in a mathematical order inherent in complex artificial entities requires us to believe that man creates more mathematically than he knows.

This argument strongly resembles the one that eventually led to Galileo's condemnation. He was required by the church to believe that mathematical models were only convenient instruments for describing and predicting nature, not expressions of an order present in nature herself. One suspects that today a similarly modest instrumentalism would be more acceptable to the high priests of the unnatural sciences than a Galilean belief in inherent mathematical order.

There is, however, one scientific problem area which suggests that the sciences of the artificial may be forced into thoroughgoing Galileanism. All branches of artificial intelligence research have encountered a major conceptual barrier—the problem of representing fields of knowledge. "Machine intelligence is fast attaining self-definition, and we now have as a touchstone the realisation that the central operations of intelligence are (logical and procedural) transactions on a knowledge-base" (Michie, 1974, page 117). This problem, according to Michie, is now the common denominator of research into artificial pattern recognition, machine translation, and even chess playing, of which Michie wrote: "As with other sectors of machine intelligence, rich rewards await even partial solutions to the representation problem. To capture in a formal descriptive scheme the game's delicate structure; it is here that future progress lies, rather than in nanosecond access times, parallel processing, or mega-mega-bit memories" (Michie, 1974, page 141).

It is hard to see how such problems will be resolved except by novel theories of combinatorial pattern formation. If mathematics is to justify its claim to be the general abstract study of pattern such theories will be assimilated to mathematics, if they are not already part of it. We cannot know in advance whether the new combinatorial ideas we need will come from mathematics, or whether they will come from outside and challenge mathematics, as physics has done so often. It may, for example, be the case that modern mathematics in pursuit of its most abstract and intangible foundations has neglected certain simpler, perhaps more imperfect, types of order than may prevail locally in ordinary space–time. If this were so, it would at least allow us to adopt a Galilean position in the sciences of the artificial without an extravagant belief in a relation between the most unworldly domains of abstract mathematics and the everyday world of practical pattern recognition, language analysis, and so on.

Whatever the solution, the existence of the knowledge problem in artificial intelligence research already strongly suggests that some formal order, of a more or less mathematical kind, must inhere in the complex entities which we 'recognise' so easily in everyday life. With only a minor extension of the argument, it may be suggested that this could be a key to the scientific study of those artificial systems which are defined on a collectivity, like cities, societies, and languages, and depend on continuous, largely unconscious pattern recognition by members of that collectivity. In this perspective a key relationship comes to the fore: the relationship between the formal structure of what there is to be known (for example, the patterns of space organisation, patterns of social networks, and so on); and the formal mental structures by which these are known or recognised. It is then an obvious hypothesis that the same formal structure could account for both.

This extension of current debates in artificial intelligence also suggests an alternative strategy for research to be conducted in parallel to the problem of formal representation of knowledge fields on the computer: that of the analysis of artificial systems like space patterns and social patterns for inherent formal structures which might contribute to their knowability.

These are the theoretical considerations that underlie the 'space syntax' research programme. They are intended both to apologise for adopting a formalistic approach to phenomena not commonly thought to be responsive to such an analysis, and also to apologise for the adoption of a practical and empirical rather than purely mathematical approach. Our aim has been to work towards mathematisation from intuitive formal principles, rather than to adopt a branch of mathematics such as topology or graph theory and work towards the phenomena. Experiments have been made in moving more firmly in the direction of one or other branch of mathematics, but each time it has become clear that this would impose severe limitations on our ability to stay close to the real evidence, and to try to draw its formal structure from it.

Perhaps a firmer argument for a 'syntactic' rather than properly mathematical strategy is that, even within the scope of a general belief in an inherent formal order giving rise to knowability in space patterns, we cannot know in advance which of the array of current branches of mathematics will be appropriate, or even if any branch will offer models for the level and type of approximation we require. The proper scientific strategy therefore seems to be to build a theory of patterns, with a close respect for the evidence but without too much regard for early justification in mathematical terms. Although we realise that we are bound to be strongly criticised for our neglect of mathematics, we hope we may be excused on the grounds that our resulting model of the formal syntax of human space organisation is at least 'unreasonably effective' in characterising the space patterns made by human societies, in showing how they were generated, how they relate to social patterns, and perhaps above all, in showing how even the most complex patterns are 'knowable' through knowledge of a few elementary concepts and operations.

In brief, our hope is to have made an effective model of the 'knowledge-field' constituted by architectural and urban space patterns. But we have done so at the price of mathematical acceptability. We therefore ask the reader to consider three things. First, the match between the model and the empirical evidence; second, the internal consistency of the model within its own limited syntactic terms, rather than in terms of its agreement with basic mathematical ideas; and third, the possibility that man-made systems involving patterns of relations, especially those defined as collectivities such as human populations, or collections of spatial domains, may *require* this syntactic level of formal analysis to mirror their real internal patterns, rather than the more searching analysis of mathematics proper. It may even be ventured that progress in developing formal theories of complex artificial systems is handicapped by not having such a level of formal analysis.

In view of the centrality of a 'syntactic formalism' to our whole research enterprise, we have developed it into an explicit theory, the theory of *morphic languages*, which appears to us to fall between mathematics and natural languages, and to offer the appropriate general concept for the analysis of complex artificial systems involving patterns defined on collectivities. As such the theory of morphic languages, and the worked example given—the morphic language of space patterns—are offered also as a contribution to the study of 'collective phenomena'.

2 The theory of morphic languages

If the problem of *knowability* is defined as that of understanding how characteristic patterns in a set of phenomena can be recognised by reference to abstract principles of arrangement or relationship, and the problem of *morphology* is defined as that of understanding the objective similarities and differences that a set of phenomena characteristically exhibit to ordinary experience, then the aim of the theory of morphic languages is, for certain classes of real, socially defined collective phenomena like spatial patterns, to unite the two problems into the single problem of understanding

how the morphology may be generated from a parsimonious set of elementary objects, relations, and operations. In effect the reduction of morphology to the elementary structure of a combinatorial system is argued to be its reduction to its principles of knowability. The set of combinatorial principles we call syntax. Syntax is the most important property of a morphic language. What is knowable about the morphological output of a morphic language is its syntax. Conversely, syntax permits the morphology to exhibit regularity in its similarities and differences.

Syntax in a morphic language is defined as a set of related rule structures formed out of elementary combinations of the elementary objects, relations, and operations. These can be introduced, independently or conjointly, in a *minimum setup* for the morphic language to produce recognisable patterns. A minimum setup is a morphic language without its syntax, that is to say, a morphic language operating randomly. More exactly, a minimum setup consists of a space[1] within which the morphic language can operate (that is, generate patterns) called the carrier space; a minimal rule of operation, that of simple repetition at random intervals; a minimal object, the least complex permitted by the system; with minimal relations, where each object has only the relation of belonging to the carrier space. It is reasonable to call such a setup 'random' since each event (that is the placing of an object) that takes place in the carrier space is independent of every other event except in that all belong to the same setup. This follows the definition of a 'chance setup' by Hacking (1965).

A morphic language therefore consists of:

a minimum setup, made up of a carrier space and a randomised ongoing process;

a syntax, that is a set of elementary objects, relations, and operations capable of being combined to form rule structures to restrict the randomness of the minimum setup; and

a syntax-rule—a rule for the formation of rules—which ideally should exhaust itself against some natural or logical limit. For example, in space syntax, the rule exhausts itself against the barrier of not being able to develop beyond three-dimensional space (in fact slightly earlier: against the fact that people cannot fly. Man-made space is effectively two-dimensional because movement is two-dimensional. Stairs are a two-dimensional reduction of a three-dimensional reality).

A morphic language links the foundation of probability (the 'chance setup') with the fundamental idea of a mathematical structure (objects, relations, and operations) from the outset. The advantages of the morphic language concept are several. First, by linking a probabilistic approach with a structural approach from the start in the modelling of phenomena, order and pattern are seen as improbable, being the result of the introduction of syntax into the minimum setup. Second, it offers, in principle, a method of keeping a record of all the order that has been built into a system. A morphic language is not decomposable into 'subsystems', but only into the syntactic rules responsible for the production of this or that kind of pattern. Even with all syntactic rules removed, the minimum setup is still, as will be shown, a relatively rich system, in spite of being minimally ordered. Third, randomisation plays a key part in the formation of certain major pattern types that appear in the real world of space patterns. Certain patterns are only produced by a generative process if the process is randomised apart from its syntactic rule (for an example, see the global pattern that emerges in generating a 3-syntactic surface on page 166). Fourth, a morphic language deals with the many minimally ordered situations that exist, in terms of a theory of patterns, that is, we may treat randomness as a special case of pattern. This turns out to be critical to the problem of relating spatial to social patterns (see section 4—

[1] Perhaps space-time would be more accurate, in which case the expression 'carrier space-time' would follow.

space and society). Fifth, a morphic language gives natural, rather than arbitrary, limits: at the lower limit is randomness, at the upper limit are the limits of realising new combinations in real space. In essence, space syntax is an exploration of the combinability of open and closed disks, and open and closed rings (assuming these to be projections onto the plane of open and closed balls, and open and closed tori). Sixth, a morphic language makes the model self-contained in that it can be shown, in the case of space syntax at least, that all the objects, relations, and operations that form the syntax, and even the syntax rule itself, can be found by an analysis of the minimum setup.

Intuitively, the postulation of a minimum setup as the basis for a morphic language means that it is assumed that people and societies deploy themselves in space, and that these deployments are capable, under certain conditions, of adopting certain patterns. The research task is, therefore, *not* to say why people deploy themselves in space, but to offer a theory of the patterns. Conceptually this is comparable to the introduction of the inertia postulate into physics. It liberates us from the Aristotelean 'essences' of universal behavioural principles, which plague current theorising about space, and allows us to build a theory of the characteristic space patterns that different types of society and organisation create.

In the theory of morphic languages, therefore, the Newtonian postulate of an ongoing system is added to the Galilean hypothesis of a formal structure inherent in the patterns of order exhibited by the states of the system. However, this formal order is not in the proper sense a mathematical order, but a *syntactic* order. But the word syntax is not used with the same technical specification or theoretical status usually assigned to it in linguistics. It is therefore necessary, to avoid misunderstanding, to be clear about the relation between a morphic language and mathematics on the one hand, and natural language on the other.

The primary purpose of a natural language (irrespective of particular linguistic 'functions') is to *represent* the world as it *appears*, that is to convey a *meaning* which in no way resembles the language itself. To accomplish the task of representation in an infinitely rich universe, a natural language possesses two defining characteristics. First, a set of *primary morphic units* which are strongly *individuated*, that is each word is *different* from all other words and *represents different things*; and second, a *formal* or *syntactic structure* which is *parsimonious* and *permissive*, in that it permits infinitely many sentences to be syntactically well-formed which are semantically nonsense (that is, effectively nonsense from the point of view of linguistic form as a whole). Conversely, meaning can be transmitted (that is represented) without well-formed syntactic structure in certain cases. The defining characteristics of a natural language are a relatively short, possibly conventional, grammar, and a large lexicon.

By contrast, mathematical languages have very *small lexicons* (as small as possible) and very *large 'syntaxes'* in the sense of all the structure that may be elaborated from the initial, minimal lexicon. Such languages are virtually useless for representing the world as it appears because the primary morphic units are not individuated at all, but rendered as *homogeneous* as possible—the members of a set, units of measurement, and so on. Mathematical symbols strip the morphic unit of all its particular properties—of being a member of a set, of existing, and so on. To be interested in the particular properties of particular numbers is, for a mathematician, the equivalent of a voyage into mysticism. Mathematical languages do not *represent* or mean anything except their *own structure*. If they are useful for representing the most abstract forms of order in the real world it is because, in its preoccupation with its own structure, mathematics arrives at *general principles of structure*, which, because they are deep and general, hold also at some level in the real world.

Morphic languages differ from both, yet borrow certain properties from each. From mathematical languages, morphic languages take the *small lexicon* (that is the homogeneity of its primary morphic units), the *primacy of syntactic structure* over semantic representation, the property of being built up from a *minimal initial system*, and the property of *not meaning anything except its own structure* (that is to say, it does not exist to represent other things, but to constitute patterns which are their own meaning). From natural languages, morphic languages take the property of being *realised in the experiential world*, of being *creatively used for social purposes* (or permitting a 'rule-governed creativity'), and of being *constitutive, rather than representative, of the social*.

Thus in a morphic language, syntax has a far more important role than in natural language. In natural language, the existence of a syntactically well-formed sentence permits a meaning to exist, but neither specifies it nor guarantees it. In a morphic language, the existence of a syntactically well-formed pattern itself guarantees and indeed specifies a meaning, because the 'meaning' is only the abstract structure of the pattern. Morphic languages are the realisation of abstract structure in the real world. They convey 'meaning', not in the sense of representing something else, but only in the sense of constituting a pattern. Thus if, as we believe, both space organisation and social structures are morphic languages, the construction of a social theory of space organisation becomes a question of understanding the relations between the principles of pattern generation in both.

This does not mean that architectural and urban forms are not used to represent particular meanings, but it does argue that such representation is secondary. To achieve representation of 'meaning' the morphic language of space does so by behaving as a natural language. It individuates its morphic units, making them as different as possible from other morphic units. Hence buildings which are intended to convey particular 'meanings' do so by the addition of idiosyncratic elaboration and detail—decoration, bell-towers, and so on. In so doing, the morphic units come to behave more like particular words in natural language. Conversely, when natural language is useful to convey abstract structure—as, for example, in academic monographs—it does so by increasing the importance of syntax over the word [see Bernstein's concept of an elaborated code, and its syntactic effects (Bernstein, 1973)]. This is why scientific interest is usually bought at the price of boredom. We cannot, alas, be poets and write scientific papers in extended metaphors.

Morphic languages are also like mathematics, and unlike natural language, in that they pose the problem of the *description*, in addition to that of the *generation*, of structure. Current linguistic theory would assume that a theoretical description of a sentence would be given by a formula expressing generative and transformational rules. This would hold even if current efforts to build semantically (as opposed to syntactically) based theories were successful. In mathematics, however, structure is only reducible to generation if one takes a strong philosophical line opposing the 'reification' or 'Platonisation' of structure, and arguing that all mathematical structure is self-evidently reducible to an orderly activity by mathematicians, not to be thought of as existing in its own right.

Whatever the solution to this problem in mathematics, in morphic languages it can be clearly shown that cases exist where the problem of describing a structure which exists objectively in the real world is over and above that of understanding how it is generated. To take a simple example, imagine that a series of individuals build square, single cell, single entrance dwellings by each joining his cell facewise onto an existing wall in the collection, keeping the growing collective object as compact as possible (that is, ensuring that the largest square obtainable by projecting the lines of cell walls is as small as possible). Given that each individual follows no other rules,

that is, ensuring the process of generation is randomised aside from its rule, then the result will be as follows:
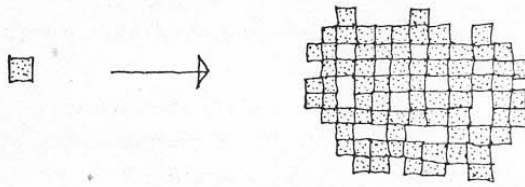
The aggregate object takes the form of a set of cells grouped around courtyards, in most cases of unit or twice unit size. In other words, although each individual only follows a *local* rule, relating only to his cell and the cell to which he joins facewise, the *global* object has a richer, emergent structure not thought of by any individual. Thus the aggregate object is not satisfactorily described by knowledge of how it was generated. The problem of describing structures, especially collective structures, thus exists over and above the problem of generating them.

In fact, the *dialectic of generation and description* appears to be of fundamental importance in the real world behaviour of morphic languages. Any ordered collective activity which is not fully preprogrammed gives rise to the problem of *retrieving a description* of the collective pattern. 'Meaning' can be seen as a stably retrievable description. The problem of understanding the growth of cities today is such a problem. Indeed, it might be argued that the role of intellectuals in society is the retrieval of descriptions. An analogy can be made with Arbib's concept of a biological self-reproducing machine (Arbib, 1969) which does not contain a permanent description of itself, but which has a facility for retrieving, at any time, a description of its genotype.

In summary, morphic languages:
are built up from a small elementary lexicon;
realise syntactic structure in the real world;
do not 'mean' anything except their own syntactic structure (in which their social purpose resides);
have both a generative and a descriptive mode.
This paper is concerned with the problem of generation only.

3 The morphic language: 'space syntax'
In the morphic language 'space syntax' the minimum setup consists of:
(a) a carrier space which is the surface of a sphere (the surface of the earth or equally some landmass on the surface of the globe); and
(b) an ongoing process of production consisting of:
   some way of marking sufficiently small parts of the surface so that they are recognisably different from neighbouring parts (if, for example, the surface was uniformly white, it would be sufficient to paint the small parts black; or to place stones would be an alternative);
   the occasional repetition of such markings; but
   without relation between one marking and the next (that is, randomly, the only relation being that each mark belongs to the carrier space).

This setup is sufficiently rich to derive by analysis all the objects, relations, and operations that constitute 'space syntax'. The 'surface', seen experientially, consists of two kinds of entity: a solid entity—the earth itself; and a vacant entity—the space we can move about in on the solid entity. This corresponds to our general experience of space. The surface consists of continuous or vacant parts, through which movement is possible, and parts occupied by objects, which impede movement

and which we therefore call discontinuities. These are the two elementary *objects* of 'space syntax'. The concept of a continuous space we refer to by the letter 'c', and a discontinuous space by the letter 'd'.

In the minimum setup, a form of demarcation that consisted only of marking the surfaces so that it is different from its neighbourhood (for example, painting it) would not affect the continuity on the surface, whereas the placing of a stone introduces a local discontinuity. Demarcations can therefore be in a continuous or discontinuous mode. Whichever of these is adopted, however, it is already implied in the minimum setup that each demarcation is finite and independent. Finiteness can be expressed as the relation of being completely contained by a neighbourhood, whether this neighbourhood is itself a continuity or a discontinuity. The relation of containing we write $\supset$, such that whatever is on the left of the sign contains whatever is on the right. Thus the expression $\supset c$ expresses the finiteness of a segment of continuous space, it not being necessary to know what contains the space, only that it is contained. Likewise, $\supset d$ means a finite solid object, or discontinuity.

It has already been observed that it is a natural property of continuous space to be permeable, whereas a discontinuous space is impermeable. The relation of permeability we write $\rightarrow$, meaning that whatever is on the left of the sign has a direct path to whatever is on the right. The expression $\rightarrow c$ therefore means that the space is permeable to whatever is on the left of the sign, and $\rightarrow d$ means that there is impermeability.

The demarcation of a carrier space by means of finite c-objects we call *differentiation*, and that by finite d-objects we call *distinction*. Each can have the property of being *clear* or *unclear*. By this we mean that it is possible to know that a differentiation, $\supset c$, is a finite differentiation without knowing exactly where the limits of the differentiation are. For example, if a white surface is demarcated by clustering black dots, so that there is a zone around the densest black dots where black dots and white areas are mixed, but eventually, sufficiently far from the centre of the cluster, there are no more black dots, then the concept of finite containment is as adequately expressed by $\supset c$ as if the limits were at all points perfectly clear. There is, however, a way of expressing the concept of clearness (as adequately as the simple expression $\supset c$ expresses unclearness) with the concepts and symbols so far established, namely to allow an object to refer the idea of containment to itself. This is already present in natural language in the term 'self-contained'—on reflection a rather odd expression— but meaning that a space-object is within its own limits. The relation of self-containment, which is argued as equivalent to clearness, can be written $\overset{\supset}{c}$. The same argument applies naturally to the $\rightarrow$ relation. A space, c, is known to be permeable in its natural state, but it has no clear paths. Paths are, as it were, nonspecific and universal in the space. The expression $\vec{c}$ means that a clear path is introduced into the space—that is, there is some set of marks which differentiate a path clearly from the rest of the space. Likewise, if the self-referring arrow is introduced to the idea of a d-object, $\vec{d}$, then it expresses the idea of a permeable discontinuity, which implies a path that passes through a d-object, not through a space, or c-object. This concept is called the nontraversing path.

The two objects, c and d, and the two relations $\supset$ and $\rightarrow$, permit the construction of an elementary lexicon, consisting of all possible elementary permutations of the terms. This is given in figure 1. It should be noted that none of these concepts are viable as independent entities. The purpose of the lexicon is to exhibit the meaning that will be given to these terms when they occur in more complex combinations in syntactic formulae. In the syntactic formulae there is always a $\supset$ sign and a $\rightarrow$ sign to the left of the formula, meaning that there is always a surrounding carrier space

and a 'carrier path' (usually implied by the carrier space), since whatever is to be created in the carrier space must be finite and accessible.

So far, two objects and two relations, together with all their elementary permutations, have been derived from an analysis of the minimum setup. Closer inspection, taking into account the elementary lexicon, reveals a more complex phenomenon. There are two forms of continuous object in the setup, those without a hole and those with at least one hole. The object without a hole is the simple c- or d-object as described. The object with at least one hole is its neighbourhood. The insertion of a finite object in the carrier space has the effect of creating a local subspace of the carrier space, possessing a hole, namely the place where the object is. The neighbourhood space, with its characteristic form, is a consequence of the placing of the object. The neighbourhood space is an emergent structure. Moreover, since not the whole of the remainder of the carrier space (recalling the 'sufficiently small' condition for the c- or d-object in the minimum setup) is the neighbourhood, then the neighbourhood must be finite. We need not be discouraged from a belief in its finiteness by our ignorance of where its limits are. This only makes it unclear, and we know already that unclearness does not interfere with finiteness. Since the neighbourhood both has a hole and is finite, then we know that it must approximate the form of a *ring*, or annulus. Thus continuous objects in the form of disks, and continuous objects in the form of rings both exist in the minimum setup:

disk   ring

If we consider each as an independent form, then it can be seen that not only is the ring an emergent structure of the disk, but also that the disk is an emergent structure of the ring. Furthermore, if d is substituted for c in the case of the ring (that is, if the ring is a d-object), then the object is a closed boundary, or enclosure.

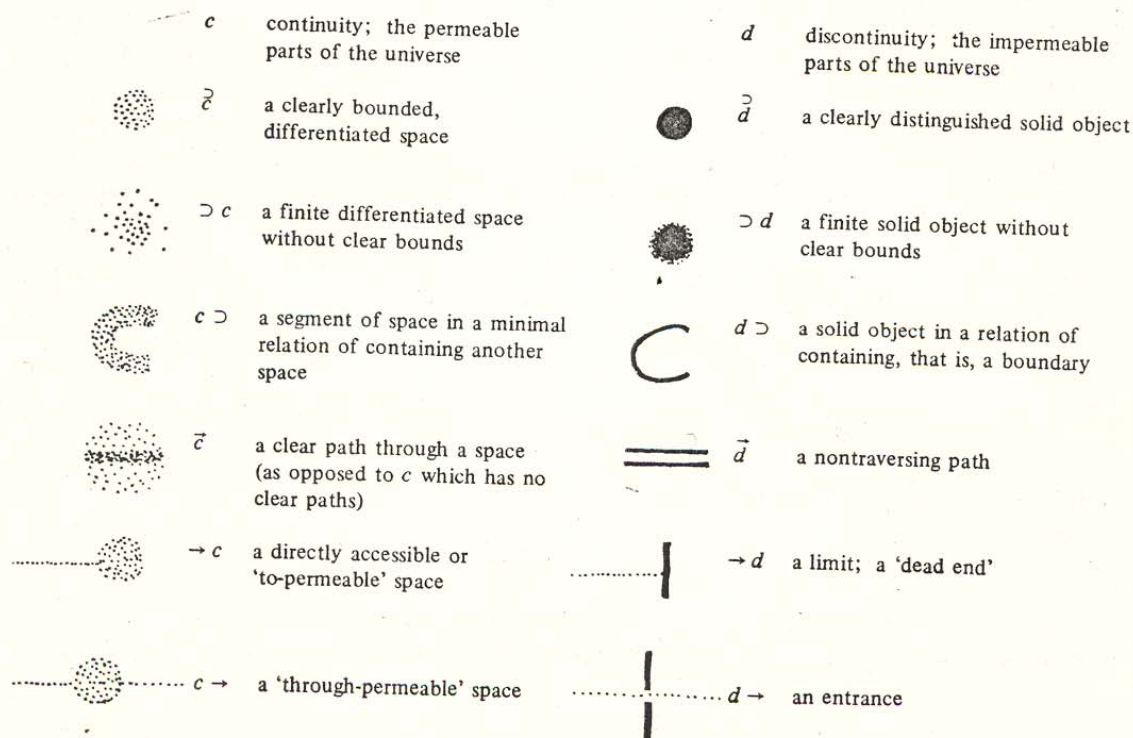|	c	continuity; the permeable parts of the universe		d	discontinuity; the impermeable parts of the universe
	$\overset{\supset}{c}$	a clearly bounded, differentiated space		$\overset{\supset}{d}$	a clearly distinguished solid object
	$\supset c$	a finite differentiated space without clear bounds		$\supset d$	a finite solid object without clear bounds
	$c \supset$	a segment of space in a minimal relation of containing another space		$d \supset$	a solid object in a relation of containing, that is, a boundary
	$\vec{c}$	a clear path through a space (as opposed to c which has no clear paths)		$\vec{d}$	a nontraversing path
	$\rightarrow c$	a directly accessible or 'to-permeable' space		$\rightarrow d$	a limit; a 'dead end'
	$c \rightarrow$	a 'through-permeable' space		$d \rightarrow$	an entrance

Figure 1. Elementary lexicon. The diagrams are illustrative rather than rigorous and are included as an aid to understanding the argument.

The enclosure together with its emergent interior disk is a more complex structure than we have so far dealt with. It consists of a discontinuous component and a continuous component in a relation in which the discontinuity contains the continuity. It is a disk with a boundary. This is a fundamental relation, and permits us (at the risk of offending topologists, who will recognise the definition, but not excuse the adaptation made of it for this purpose) to introduce a definition: an object is *closed* if it has its own boundary; otherwise it is *open*. We can therefore call

◯ a closed disk, and ⬤ an open disk.

The distinction between open and closed space objects, together with the syntactic rules for constructing open and closed objects, is perhaps the most fundamental in space syntax. The property of being closed is *not* the same as that of being *enclosed*. For example, consider a group of contiguous closed disks grouped around a central space (a 'courtyard' form),

On the given definition, the central space is an *open* disk, in spite of being completely enclosed, since all the boundaries belong to the surrounding disks not to the central space. In contrast, we have the 'house and surrounding garden' form,

The garden is a closed disk (although 'open' with respect to the 'house') since it has its own boundary. By the same argument, streets are 'open' spaces, whereas the allegedly 'open' spaces of the average 'estate' are in fact closed.

The purpose of this preliminary analysis of the minimum setup has been, first, to show that certain basic forms are syntactically inevitable once the plane is demarcated by any spatial process, apart from simply moving about on it. There is therefore no need to speculate about basic human 'drives' or 'preferences' for certain space forms. Second, to show that even the most random structures are syntactically rich if we are prepared to analyse them, and we must consider that this may be a fundamental aspect of human spatial experience—to make space yield its syntactic riches by cognitively and experientially retrieving its structure—and third, and most important, because, as we hope the examples of open and closed forms show, it is the fundamental distinctions and the most elementary properties of space objects, that enable us to analyse far more complex syntactic setups. We find, with Herman Weyl that:

"What is decisive is this: the farther the analysis progresses, the more detailed the observations become and the finer the elements into which we dissect the phenomena, the simpler—and not the more complicated, as might be expected—become the basic laws, and the more completely and accurately do they explain the factual course of events" (Weyl, 1963, page 147).

We hope to show that this is the case in the presentation of the syntax proper.

No description in the ideography has yet been offered of the ring and the closed boundary. Nor have any operations been described, apart from the most elementary operation of repetition in the minimum setup. The two questions are related since, although the existence of a neighbourhood ring may be inferred from the minimum setup, it can only arise as an independent entity if an *operation* other than repetition is performed. This is particularly clear in the case of the closed boundary (assuming

we are on the surface of the earth, rather than cave dwellers). In terms of the minimum setup, the existence of a closed boundary is most improbable.

Given the ongoing process of production in the minimum setup, *an operation assigns one or more of three numbers to a configuration of objects and relations, the numbers being: one, two, and many*. The numbers 'one' and 'many' are already implicit in the minimum setup in that each minimal operation adds one new object to the carrier space, and the result of such a process of repetition will be 'many' objects in the carrier space. The concepts of 'oneness' and 'manyness', both fundamental to the syntax, may therefore be said to be derivable. The concept of 'twoness' is more difficult, since it appears to be excluded by the definition of the minimum setup itself, which defined the randomness of the setup in terms of lack of a relation between two demarcations in the carrier space. The concept of 'twoness' is present in the ring but, since this is not obvious, we must take the argument a little farther, then return to look at the problem of describing the ring in the ideography.

Since, as has been shown, an object placed in the carrier space has an unclear neighbourhood, it is evident that after a sufficient period of random operation of the minimum setup, a case will arise in which one object is placed sufficiently near to, or even within the neighbourhood of, another. Suppose the two objects to be *c*-objects, that is, open disks. In such a case, by following the form of reasoning which led to the identification of the neighbourhood ring of an object, there will be a subspace of the neighbourhood rings of each which will coincide. A word exists in natural language to describe such a relation—*between*. 'Betweenness' is a relation dependent on two objects having a spatial relation to each other. The space 'between' emerges from the relation of the two objects. Further, if the concept of 'neighbourhood' was emergent from the placing of an object in the carrier space, the concept of 'neighbour' is produced from the juxtaposition of two objects. If two objects are placed in the carrier space, sufficiently close for their neighbourhoods to overlap, then there will be a subspace of the carrier space which is common to neighbourhoods of both.

There is also a natural expression in the syntactic ideography for the relation of betweenness and, therefore, of 'twoness', viz the expression which says that the relation of containing belongs to a pair of objects, rather than to a single object. We might provisionally write this in the form: $c_1, c_2 \supset c_3$, meaning that each object to the left of the $\supset$ sign takes part equally in the relation. Thus it can be seen that if there is exactly one term to the left of the $\supset$ sign, it gives rise to the concept of 'insideness', and if there are exactly two, to the concept of 'betweenness'.

We may now introduce into the ideography a notation for 'oneness', 'twoness', and 'manyness'. Round brackets, ( ), will mean one; broken brackets, ⟨ ⟩, two; and brace brackets, { }, many. In effect this means that two is ⟨( )( )⟩, and many might be written {( )( ) ... ( )}. More complex syntaxes may now be constructed, and we begin by trying to solve the problem of describing a ring.

The first observation made about the ring was that, in contrast to the disk, it possessed a hole. A topologist would say that the two forms were therefore topologically nonequivalent, describing the disk as an object of genus-0, whereas the ring was an object of genus-1. The question becomes: how can this topological difference be represented syntactically, and in the syntactic ideography?

The answer lies in the *application of the ideas of twoness and betweenness to a single object*. A single *c*- or *d*-object may be 'stretched' in such a way that it *recognisably has two ends*, say,

 ,

which would be represented in the ideography by the expression: ⟨*c*⟩. *To arrive at*

*the ring form we add the 'betweenness' common product of this pairness in such a
way as to ensure that the resultant object does not degenerate topologically to a disk
again, that is, it must have a hole.* This complete transformation may thus be written
$\langle c_1 \rangle \supset c_2$ (meaning: a continuous space bifurcates and is joined to itself by a further
similar space, thus forming a single continuous ring), noting that it is a finite continuous
single object, and therefore $(\langle c_1 \rangle \supset c_2)$, and also that it contains a disk as its emergent
product: $(((\langle c_1 \rangle \supset c_2) \supset (c_3))$ (meaning: the continuous ring contains a disk). By
treating the ring itself as the object (that is, regarding the interior disk as emergent
but not a participant in transformation) we may then perform the same transformation
again: $\langle\langle c_4 \rangle \supset c_5 \rangle \supset c_6$ [meaning: a continuous ring bifurcates again (note *not* the
internal disk) and is joined to itself by a similar space thus forming a double ring]
with the result that we have a continuous object with two holes. This process may
be continued to create as many holes as we please, and thus raise the genus of a
continuous object as high as we please. Beginning with a *d*-object, and performing
the same transformation, we arrive at the concept of a closed boundary, or *enclosure*:
$(\langle d_1 \rangle \supset d_2)$ and $\langle\langle d_3 \rangle \supset d_4 \rangle \supset d_5$ [2]. In space syntax the *d* version is the normal form
for this object, whereas the normal form for the untransformed object is the *c* version.
These two objects are 'boundaries' and 'spaces' respectively, or, taking into account
the space inside the boundary, closed and open disks. The homologous → formula,
→ $\langle(\,)\rangle$ → $(\,)$, interprets this concept for a path, namely the path that bifurcates and
meets itself, thus forming a ring.

   With this language of two elementary objects, *c* and *d*, two elementary relations,
$\supset$ and →, and three bracketing conventions, $(\,)$, $\langle\,\rangle$, and $\{\,\}$, the possible types of
operation[3] that may be introduced into the minimum setup can be explored. The
present hypothesis is that there are *eight* major types of operation, and therefore eight
major types of 'syntax', all of which give rise to a principal type of settlement pattern
and/or architectural complex, and whose use singly or in combination provides a
method for the analysis of architectural and settlement patterns, and the morphology
of building complexes. Each of these eight major syntaxes will be described in words,
and expressed in the ideography in the simplest possible way (so as to make as clear
as possible the relations between the syntaxes), then examined in more detail. At this
stage, it is hoped that the introduction of the ideography will be justified, since it
enables us both to keep an exact record of all that has been said about a pattern, but
also allows us to express complexes of spatial relationships that in verbal form would
be hard to follow, and even harder to formulate.

The eight major syntactic operations
Operation 1. The first syntactic operation is the one already present in the minimum
setup (it will be shown shortly that this is already richer than has been described),
which says, in respect of the ongoing process: *from each to the next: no relation.*
Assuming the carrier space is to the left of the leftmost relation sign (as is always the
case), there is a natural expression for this operation in the ideography:

$$\supset (\,)(\,)(\,) \ldots (\,).$$

This says that the carrier space contains an object, and another object, and another,
and so on. The simplest possible expression for this operation would express this
relation for the first two objects, $\supset (\,)(\,)$.

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[2] At this point in the text subscripts are discontinued.
[3] The term 'operation' will be used when relations and 'numbers' of objects are specified in a
general way. When specific objects are added, such that the formula expresses a definite morphology,
the term 'rule structure' or simply 'rule' is appropriate.

Operation 2. The second syntactic operation is based on the transformation that produces the ring or closed boundary, and it says, in respect of the ongoing process: *from each to the next: the same unitary object*—this being the effect of repeating the transformation, producing a multicellular unitary object[4]. The expression for this is,

$$\supset (((((\;)\rangle \supset (\;))) \supset (\;)),$$

or taking into account only the unit bracketing structures,

$$\supset ((\;)),$$

since at each step the new object is made part of the old, with the above bracketing effect.

Operation 3. This operation combines these two ideas into that of a randomly growing but continuous aggregate, whose formal operation says in respect of the ongoing process: *from each to the next: the next is added as a neighbour to the aggregate formed by all previous objects.* This might be termed the 'pairwise growth of an aggregate', since at each step the aggregate thus far (even if it is only one object) becomes the first member of a pair, and the next object becomes the second member of the pair, these being joined in a neighbour relation onto each other. This retains the idea of randomness, while introducing the concept of an aggregate object, and pairwise could be expressed,

$$\supset \langle\langle\langle(\;)(\;)\rangle(\;)\rangle(\;)\rangle,$$

but more simply, the concept of a randomly growing but continuous aggregate is given by

$$\supset ((\;)(\;)).$$

Operation 4. The fourth syntactic operation maintains the concept of a continuous aggregate object, but instead of placing each new object in a neighbour relation to the aggregate of previous objects, it places it in a *neighbourhood* relation—that is it requires each new object to *surround* the previous. The operation therefore says in respect of the ongoing process: *from each to the next; the next is a neighbourhood of the aggregate formed by all previous objects.* The effect of this is an expanding concentric structure, which can be formally expressed as

$$\supset ((\langle\langle(\;)\rangle \supset (\;)) \supset ((\langle(\;)\rangle \supset (\;))),$$

or, as simply as possible,

$$\supset ((\;) \supset (\;)).$$

It is important to note at this stage that the second and fourth operations are unlike the first and third in that they use the concept of surrounding, which requires them to be composed of an object of the form, $(\langle(\;)\rangle \supset (\;))$, rather than objects of the form, $(\;)$, which will serve for the other two which do not invoke the idea of surrounding. This accounts for the relatively greater complexity of the formulae for the second and fourth operations. This will shortly be seen to be one of the fundamental dimensions of variability for syntaxes.

The four operations so far described are all *local* rules which, when applied to the ongoing process of aggregation in the minimum setup, have certain *global* results

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[4] This is, if the historical evidence and our syntactic interpretation of it are to be believed, the origin of the concept of a complex building—the analysis of complex building being the analysis of the space and path structures that can be defined on such a structure.

(which will be discussed shortly). By local we mean that the operation works in a 'step-by-step' way, as embodied in the expression 'from each to the next'. The next four operations prescribe not a local rule, leading, under repetition, to a global outcome, but the global outcome itself, in such a way as to impose local, step-by-step order. *In other words, the first four operations control the process in local-to-global fashion, whereas the next four introduce global-to-local control.* Note that there is a relationship between operations 1 and 5, 2 and 6, 3 and 7, and 4 and 8, although this does not exhaust the interrelations.

Operation 5. The fifth operation introduces the global idea that each object produced by the ongoing process takes part in the containment of a single object. *The operation therefore says: each next object becomes part of an aggregate which contains another object.* Note that this specifies no other relation between individual aggregate members, and these can therefore be random, or emergent. Aggregate continuity is guaranteed only by the rule that relates all objects to a single object in an aggregate neighbourhood relation. Perhaps unexpectedly the introduction of a global rule has the effect of making the object finite (in all but a few variants), since the overall shape is, as it were, decided in advance, and the placing of the individual objects becomes a matter of filling available spaces from which the rule can be obeyed. To express this fully, we must say that the aggregate of objects takes the $(((\ )) \supset (\ ))$ form, that is, it behaves like a ring or closed boundary,

$$\supset ((((\{(\ )(\ ) \ldots (\ )\}) \supset (\ )) \supset (\ )),$$

but at its simplest the global object is described by

$$\supset ((\ )(\ ) \supset (\ )).$$

Operation 6. The sixth syntactic operation introduces the global idea that a single object contains the aggregate, that is a single object is the neighbourhood of an aggregate. As a neighbourhood object, the single object must have the form $(((\ )) \supset (\ ))$. The operation therefore says in respect of the ongoing process: *each next object becomes part of an aggregate which is contained by another object.* This can be expressed as

$$\supset ((((\ )) \supset (\ )) \supset \{(\ )(\ ) \ldots (\ )\}),$$

or more simply as

$$\supset ((\ ) \supset (\ )(\ )).$$

Note that there is no relation among members of the aggregate other than being contained by the same global object.

Operation 7. The seventh operation, like the fifth, defines a global object in which a single object is to be contained by an aggregate, but it adds that one part of the aggregate is containing another part, and the single object contained is between them, that is, contained by both. This has the effect of making the single object into an enclosed ring (if the fifth operation generates 'plazas', the seventh initially generates 'ring-streets', an equally pervasive form). The operation therefore says: *each next object becomes part of one of two subaggregates, one of which contains the other, and which between them contain a single object.* This may be expressed as

$$\supset ((\{(\ )(\ ) \ldots (\ )\} \supset \{(\ )(\ ) \ldots (\ )\}) \supset (\ )),$$

or more simply as

$$\supset (((\ )(\ ) \supset (\ )(\ )) \supset (\ )).$$

Operation 8. The eighth operation reverses the seventh in much the same way as the sixth reverses the fifth: two single objects one inside the other have between them an aggregate. This means that the aggregate unfolds itself within two objects of the form $(\langle(\ )\rangle \supset (\ ))$, one of which is inside the other. The operation therefore reads: *each next object becomes part of an aggregate which is contained between two objects one of which contains the other.* This may be written

$$\supset (\langle\langle\langle(\ )\rangle \supset (\ )\rangle \supset (\langle(\ )\rangle \supset (\ ))\rangle \supset \{(\ )(\ ) \ldots (\ )\}) ,$$

or more simply as

$$\supset (\langle(\ ) \supset (\ )\rangle \supset (\ )(\ )) .$$

From operation 1 to operation 8 the increasing complexity of syntax formulae expresses the increasing degree to which the 'global' structure prevails over the 'local', with the highest numbers having the most global structure. Therefore it is reasonable to say that patterns built from strong global operations have 'more' order in them than 'locally dominated' syntaxes. This does not mean that 'local' syntaxes do not have global structure; they have very strong global structure, but it is a global structure that emerges from the ongoing process, under the influence of its rule. These emergent patterns will shortly be examined in more detail.

Inspection of the eight formulae reveals another principal dimension of variability which occurs between the odd and even numbered syntaxes. If we begin with an initial object and consider the way a particular syntactic operation builds on it, it can be seen that even-numbered syntaxes, after 2, build control to the left of the initial object (as though the initial object were the linguistic 'object' of the formal 'sentence', and the left-added structure were the 'subject' of the 'sentence'), which always has the 'surrounding' form $(\langle(\ )\rangle \supset (\ ))$, taking the form of a single object. In contrast, odd-numbered syntaxes build to the right of the initial object, accumulate, and allow the accumulation to control whatever is built to the right (as though the initial objects were the 'subjects' of the 'sentence', and the added structure was the 'object'). This is the formal difference between *distributed* and *nondistributed* syntaxes. In distributed syntaxes, the odd-numbered syntaxes, every primary object plays an equal part in constructing the global pattern (whether this is globally defined or emerges from a local operation), and the aggregate therefore predominates. In nondistributed syntaxes, the even-numbered syntaxes, there are always one or more unitary loci of control externally placed on the aggregate, which impose a superordinate control on it, and therefore the unitary object predominates. To use a contemporary illustration of this fundamental distinction, a street-pattern is a global distributed syntax, whereas a high-rise estate is a global nondistributed syntax. The shift from distributed to nondistributed syntaxes is one of the fundamental dimensions of the shift to urban space patterns in the past century or so.

It is hypothesised that these general dimensions of variability of syntaxes (local-to-global and global-to-local, distributed and nondistributed) can be well ordered in terms of the model presented in figure 2, which shows the interrelationships of all the syntaxes by showing how they are derived from one another. The model initially postulates that operation 2, $(\langle(\ )\rangle \supset (\ ))$, is the 'prime' of operation 1, and from there operation 1 is combined with operation 2 to make syntax 3, then 3 is primed to make syntax 4, then 4 is combined with 1 to make operation 5 and with 2 to make operation 6, then with 3 to make operation 7, and then operation 7 is primed to make operation 8.

Alternatively the eight syntaxes may be seen as the unfolding of the following rule
for forming syntax rules (or 'rule-rule'), imposed on the minimum setup:
(a) if ( ) ( ) then add as many as you like (that is, if two objects are juxtaposed in a
formula without a relation between them, then the two can become many);
(b) if ( ) ⊃ then ( ) remains one (that is, if a relation sign follows one object in a
formula, then it remains as one);
(c) if ( ) ⊃ then ( ) is (⟨( )⟩ ⊃ ( )) (that is, if an object contains, then it is a ring).

In other words, given the generic difference between syntaxes 1 and 2, we have
simply explored the possibility of shifting brackets relative to relation signs, until all
more complex versions that can be unfolded on the carrier space must be combinations
of these. The eight are the fundamentally different types of syntax.

In order to embody these abstractly stated operations in rule structures in the full
sense, so that they can be imposed on the minimum setup to give real space patterns,
which may then be compared to reality and made the subject of a sociospatial theory,
we need to build objects into the operation formulae. This can be done by means of
two simple additional rules. The first is justified by the observation that the normal
form of an independent structure of the form (⟨( )⟩ ⊃ ( )) is (⟨d⟩ ⊃ d), that is, the
enclosure that makes the closed disk. Since we have already defined this form as the
'prime' of the open disk and assigned it to the family of nondistributed syntaxes, we
may also regard (⟨d⟩ ⊃ d) as the elementary nondistributed, or 'primed', object.
Conversely an open disk is the elementary distributed, or 'unprimed', object.
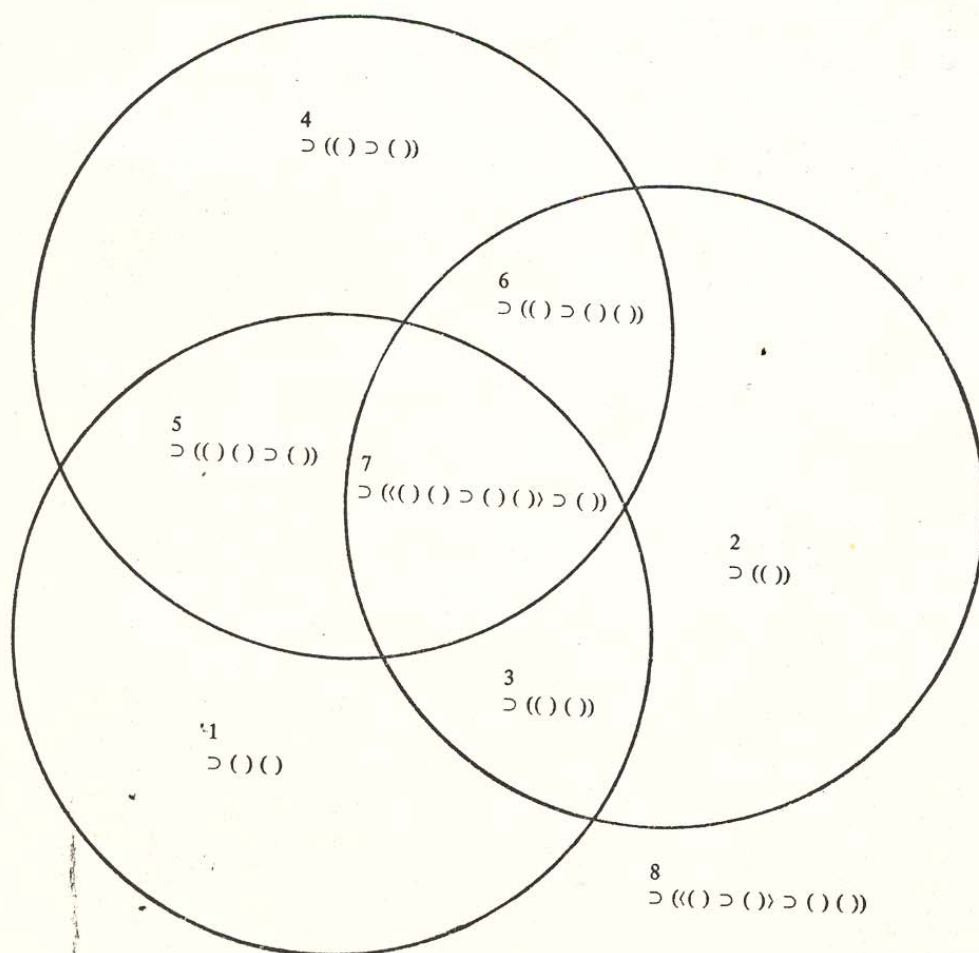

Figure 2. Evolutionary relations of syntactic rules.

The second follows from the definition of 'open' and 'closed' objects given earlier; namely, that an object is closed if it has its own boundary. From this we say that an object will be closed if it takes part in containing. Note that these are not strict rules but conventions which give rise to the normal, real space forms of the syntax. In fact the exceptions to these conventions are often interesting and informative.

Syntactical analysis applied to some existing forms
We may now look more carefully at the syntaxes[5], and offer a new way of approaching a number of classic problems in the morphological study of settlement patterns, and the evolution of architectural and urban form. In this discussion, reference will not be made to social and organisational variables, since these are dealt with as a whole in section 4 which outlines a general theory of the social formation of space patterns.

Each of the eight syntaxes gives rise to an elementary object, namely that constituted by the least possible interpretation of its operation, with regard for the relations between open and closed objects, and distributed and nondistributed syntaxes. These are given in figure 3.

It may or may not be noteworthy that if each space and each boundary are counted as an object then each 'least object' has exactly the number of objects of its syntax number. This may be fortuitous, or even contrived, or it may be simply the general result of a 2-object being more complex than a 1-object, a 4-object being more complex than a 3-object, and so on.

The 'least' object is the natural starting point of a syntactic process, and gives its dominant morphological realisations in most cases. On the other hand, it is not a necessary starting point. Much of the variability of syntactic forms comes from variation in the 'least objects' of which the global pattern is constituted. For example, a global 5-form may have 4-objects as its constituents, and so on. In particular, most examples of 1-syntactic settlement patterns have fairly complex objects fed into the 1-syntactic process. The arguments set out in section 4 of this paper suggest why this should be so.

The most important product of each syntax is the global pattern produced when the syntax is defined on the minimum setup for a sufficient period for emergent
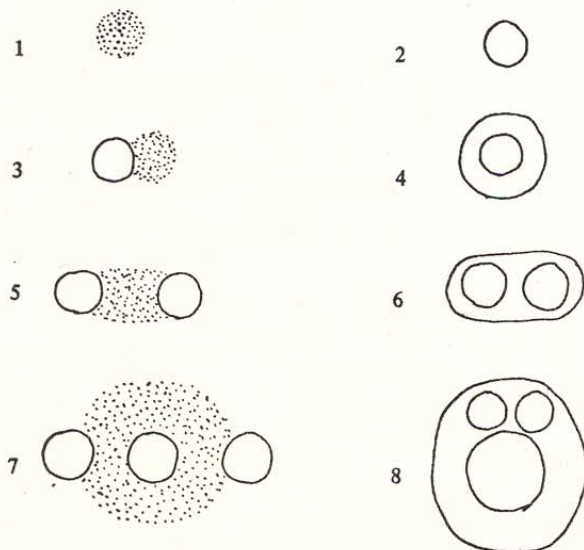

Figure 3. Elementary syntactic objects.

[5] In the following discussion the reader is advised to refer to figure 19, pages 176-177.

patterns to appear. This is particularly important for the distributed syntaxes, beginning with the 1-syntax, which has not quite yet extracted all the riches from the minimum setup.

When the minimum setup was first defined, it was not specified whether or not the carrier space should be regarded as being bounded. In taking the surface of the globe, this problem was avoided. But this is a little unrealistic. The 1-syntax defines its own carrier space in the following way. The first object is placed at random, and then another an arbitrary distance away, in an arbitrary direction, possibly following topographical or resource constraints. By this time it is possible for the third object to treat the zone within which the first pair can be thought to lie as the carrier space to which it will relate. As the process develops, each object as it is placed will either be surrounded at some distance by other objects, in which case it will not be near the edge of the evolving carrier space, or it will be only partly surrounded by other objects, in which case it will be near the edge, or even outside. If this latter case arises, then the next object will be placed back in the region of the other objects in order to follow the rule of belonging to the carrier space. Thus the 1-syntax adds a small measure of structure to the minimum setup, in the form of a local rule comparable to that which René Thom (1975) argued maintains the spatial coherence of a cloud of mosquitoes—that if each mosquito, while moving randomly with respect to each other mosquito, sees half his field of vision free of mosquitoes, he moves in the direction of mosquitoes. This is, we believe, the minimum syntactic rule for a spatially coherent aggregate, and *its global result is that, through the distributed repetition of its local rule it defines the carrier space.* Thus there is a means of producing global differentiation in the man-made landscape without the invocation of boundaries, and even without a clear idea of the limits of the carrier space of a particular collection (that is, members of a society who place objects on the land). Thus in a 1-syntax, the 'smallest object' is what was earlier defined as a *differentiated space*—an open disk which is recognisable by virtue of being differentiated rather than distinguished by a boundary—and the global structure that results is also a differentiated space—*the large open disk that now constitutes the carrier space.*

There is also a 1-syntactic path-structure (all syntaxes have space forms and path forms) which arises by an exactly analogous process. As each object is added it carries a path from the last, thus generating a *carrier-path* analogous to the carrier space. As the surface becomes dense the paths inevitably form nets, and the net is the global path-syntax associated with the 1-syntax. Its simplest interpretation is 'being strung along a path', which is one of the most important, albeit minimal, determinants of settlement patterns. The capability of the model to describe such minimally ordered space and path setups in a unified theory is, we hope, one of the justifications for the rather elaborate construction of the concept of a morphic language.

A settlement pattern, which we would now call 1-syntactic, has been described by the anthropologist Fortes (1945). Writing of the Tallensi, a tribal society of considerable intricacy, with highly structured households, Fortes observed that the landscape of Taleland (the global, open disk, boundaryless carrier space) had the following appearance:

"From the top of the Tong hills, looking northwards, one has a view of what seems to be an endless plain, dotted meagrely with trees and studded closely, as far as the eye can reach, with homesteads. They are identical in appearance, squat, circular, drab-grey or red, like the soil itself, mostly thatch roofed, and seem to be scattered indiscriminately, some close together, others further apart. There is nothing to indicate where one settlement begins and another ends" (Fortes, 1945, page 155).

Figure 4 shows a segment of the pattern. The settlement structure of the Tallensi also includes other randomly placed spaces, not shown on the illustration, which are their 'sacred places' or 'earth-shrines'. These are not enclosures but "groves of trees, a pool or stream, a pile of boulders, a single prominent tree, or simply a bare patch in the fields". This is a fair sample of the possible methods for demarcating the landscape without boundaries. It shows the Tallensi are being consistent. For their sacred spaces they use 1-objects; for their settlement patterns the 1-syntax. For other examples of this, or similar patterns, see for example Vogt (1968) on Zincantan in Mesoamerica, and also the observations of Sahlins (1974).

The 2-syntax also features prominently in the record of the evolution of settlement patterns. A very pure example is the multicellular 'kiva-block' at Kaituthlanna (Roberts, no date) which appears as an antecedent to the classic ruined pueblos of the American Southwest. Figure 5 shows the characteristic form, lacking internal connection between the separate cells (these arise later). The large cell is the kiva, which was probably the original built form; the multicellular structure is, as it were, 'unfolded' from the kiva outwards. Again there is syntactic consistency between the use of the simple 2-object for the sacred space, and the 2-syntax for the settlement model. The ethnographer from whose work this illustration is taken, having taken for granted that the structures must be 'defensive', commented that this could hardly be the case since they could easily be attacked from above, there being an overhanging cliff available. This is a typical example of the failure of simple 'causal' explanation of built forms and settlement patterns, and their rejection by many ethnographers. The 2-path syntax associated with the 2-space syntax is a series of path segments leaving the carrier path at intervals, and each arriving at a limit, or dead end. Back-to-back housing is the nearest modern version of this morphology, although early examples including possibly Catal Huyuk (Mellart, 1967), thought to be the world's earliest town, appear to have an analogous form.
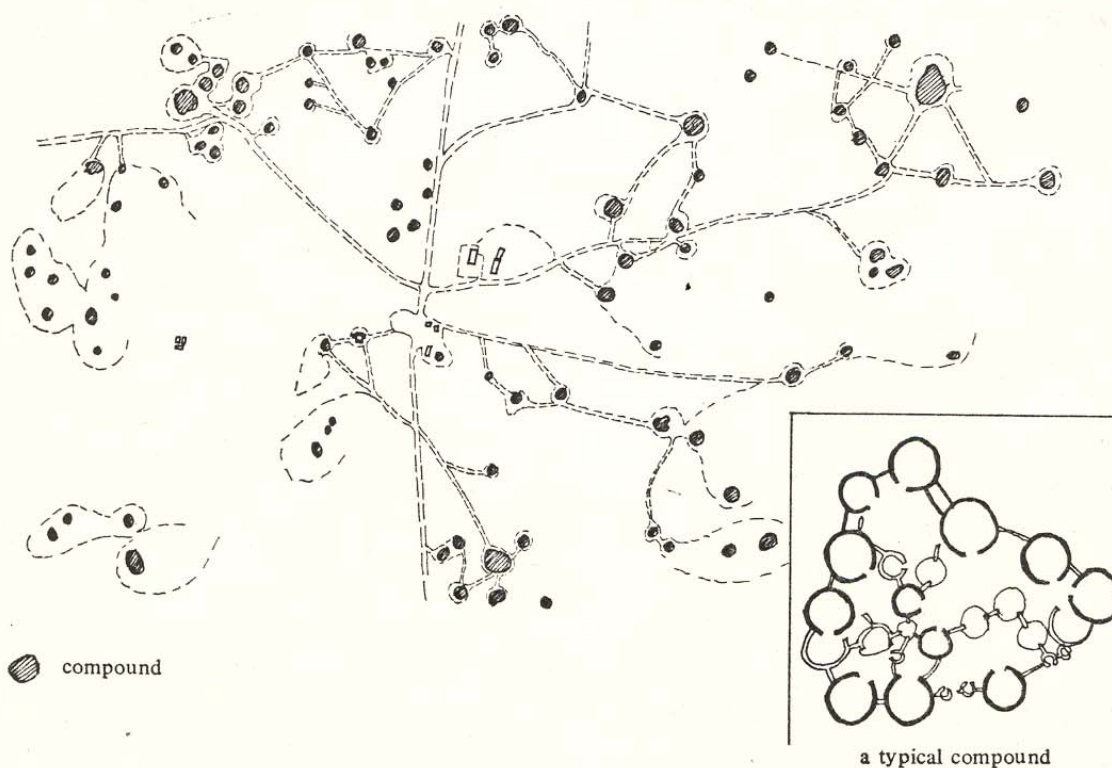

◍ compound

a typical compound

Figure 4. Tongo—a Tallensi settlement (after Prussin, 1969, pages 56, 59).

The 3-syntax is one of the most widely used forms of settlement organisation, and examples, varying in density and small object composition, have been found in the ethnographic records of many parts of the world. It is still a dominant urban pattern in certain parts of the world and, for example, survives in parts of the City of London. The most initially surprising aspect of the 3-syntax is its global form, or rather its family of global forms. These can be discovered by means of simple experiments, either with pieces of black and white card, or even with pen and paper.

If the setup has for its object the 3-object,

and a 3-syntactic rule (continuous random aggregation) is applied, requiring objects to be joined facewise (there is a universal syntactic rule forbidding the joining of rectilinear forms by vertices) by the open disks (if we require both components of the 3-object to be facewise joined, then the only result will be a linear string—this occurs frequently, but is not our immediate object), then provided the process is properly randomised the following type of global pattern will begin to emerge:
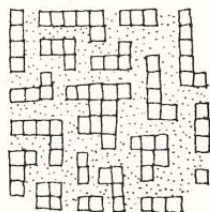
This is an oversymmetrical version of the global syntax, since the process was carried out as though on a grid to show the rule working. The defining properties of the global pattern are that
(a) a continuous structure of asymmetrical open space is unfolded, varying in width, and containing at odd intervals what may be called 'beads'—in fact, this form is known to us as the 'string of open beads';
(b) this open space structure eventually forms rings, so that there are always 'two ways round' from any point to any other point—it becomes 'rings of open beads' (unless there are additional constraints that force it to unfold linearly and remain 'strings');
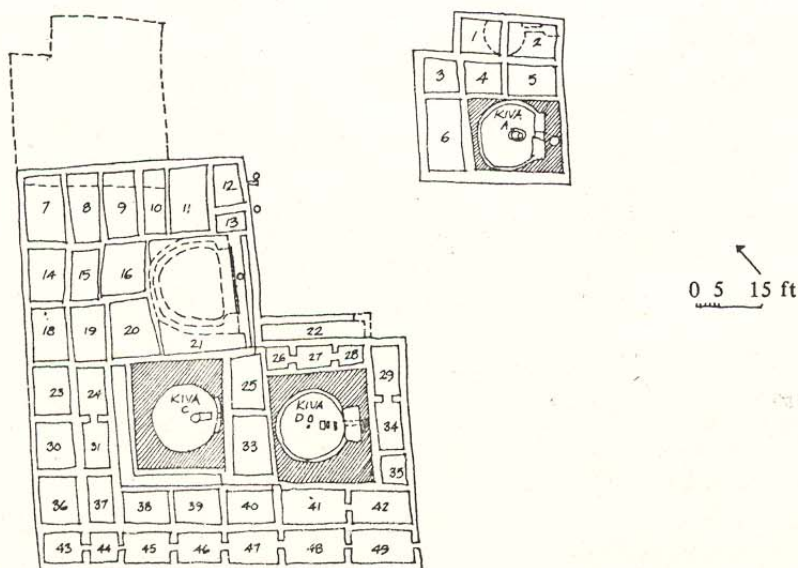

0 5   15 ft

Figure 5. Pueblo ruin at Kiatuthlanna (Roberts, no date, pages 91-92).

(c) the closed disks of the 3-object are divided into islands or clumps by the formation of the rings; with the result that

(d) every closed disk (in effect the dwelling) is directly attached to a potentially infinite, and intricate, open space structure, and will almost certainly be near a 'bead' of some kind, that is, a larger piece of open space;

(e) the 'rings' thus formed are both open and enclosed in the senses already defined.

It should be noted that apart from these strong structural properties, the asymmetry of the pattern is a syntactic product, a result of the inherent improbability of geometrical order in the minimum setup.

This settlement form, which will be the subject of a separate monograph, has often been noted by writers on settlement morphology, but usually classified either as 'disordered', or simply as 'nucleated', 'clustered', 'organic', or some other somewhat unhelpful term. The syntactic analysis reveals the profound spatial ordering of such settlements, a fact easily appreciated by the average tourist, if not by the average morphologist. Figures 6 and 7, Muker and Hawes, both in the Yorkshire dales, show a very small settlement and a small English town at different levels in the unfolding of a 3-syntax.

As frequently happens, in Hawes the back areas of the 'island' aggregates become closed off, but the general syntactic form remains. Here there is both a 'string of open beads' (the narrow part) and 'rings of open beads' (the broader section growing randomly, and therefore in all directions). The path syntax associated with this pattern is one in which a path segment leaves the carrier path, and eventually returns to it by another route: the nonlimit sequence. There is a sequence of traversals, but no dead ends.

In contrast to the 'profanity' of the 3-syntax, the 4-syntax (with its associated path structure, the 'limit sequence', that is a sequence leading to a 'deepest space') is strongly associated with the sacred. Sacred buildings, from English churches to the
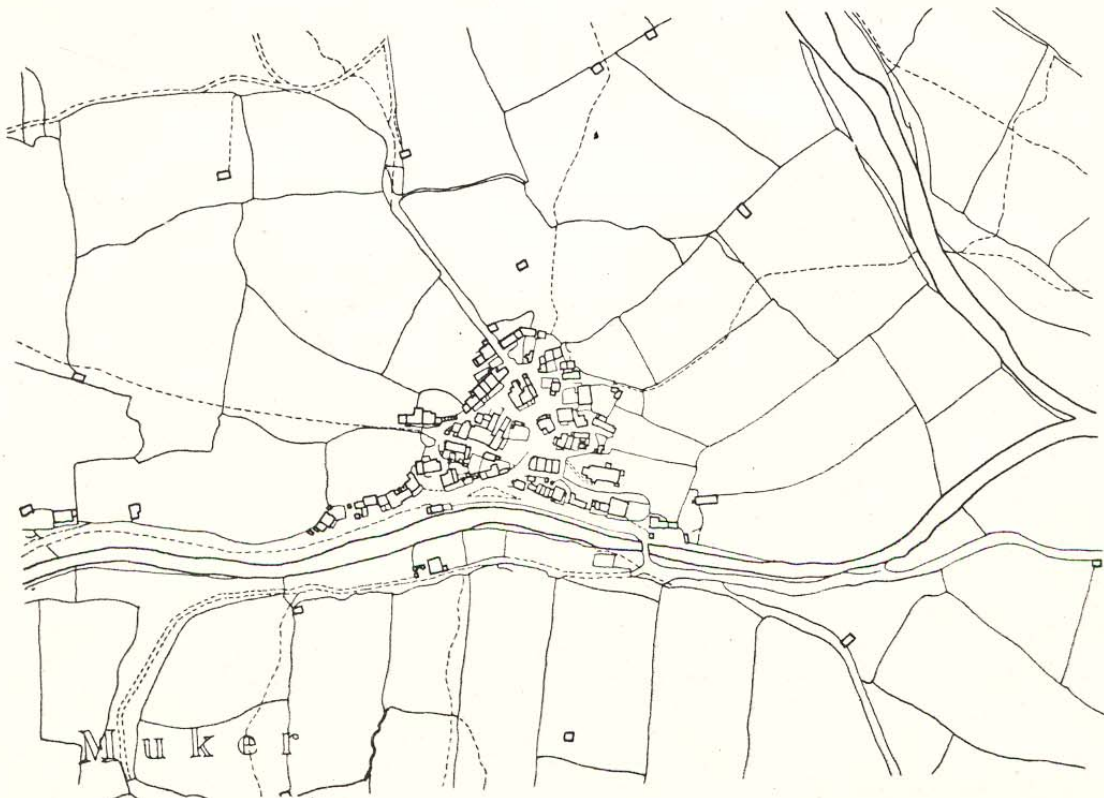

Figure 6. Muker (after OSC, 1888–1893).

Summer Palace in Peking, have concentric overall morphologies, and explore the path concept of a limit sequence. Most interesting are the variants of the 4-syntax. For example, there are a pair of forms which use the 4-rule to make a concentric object, but make it from an open and a closed disk rather than from two closed disks. One is the closed disk which defines an 'open space barrier' around itself—that is the open contains the closed,

the other is the 'cloister' morphology, in which the closed contains the open,

Suburban morphologies are usually based on 4-objects. The open type of American suburb is based on the 'open space barrier' morphology; the British suburb on the basic double closed disk. In the more compressed urban setting, the sequence is substituted for the full concentric form.

Thus each of the first four syntaxes leads to emergent structure, that is more structure than was specified in the syntax rule. What is less obvious is that each defines as its emergent structure one of the four basic objects of the syntax. The 1-syntax generates an open disk; the 2-syntax the closed disk; the 3-syntax the open ring; and the 4-syntax the closed ring. We are far from clear why this should be so, nor are we clear if it is significant. It does happen, however, that, in the same order, the emergent forms become the defining properties of the next four syntaxes. We thus move on from the 'step-by-step', or 'local-to-global' cases, in which these structures emerge *from* an aggregate, to the 'global-to-local' cases where the structures are defined *for* the aggregate.
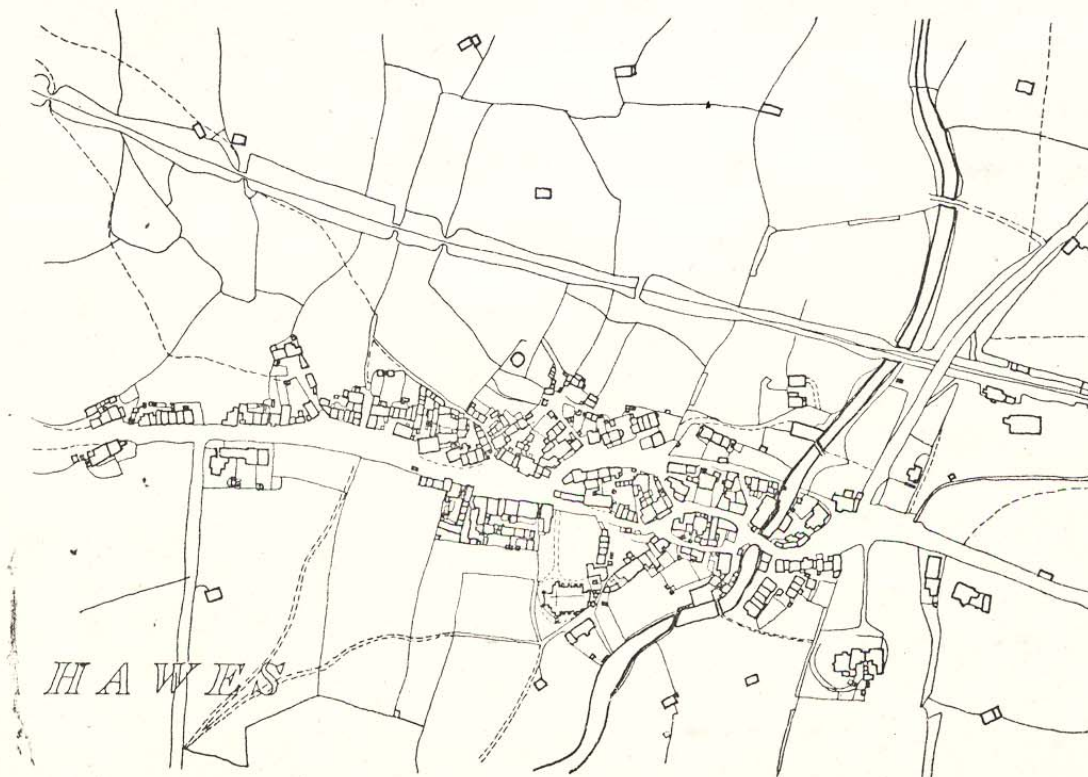

Figure 7. Hawes (after OSC, 1888–1893).

The 5-syntax generates a family of forms that are both well known and well recognised, possibly because they are often geometrically fairly obvious. Also, because the form is a simple one and also finite, it occurs at many levels. At the simplest level, the 5-syntactic defining property of an aggregate containing (that is constructing) an open disk generates the simple courtyard form in its various realisations, including the version arising from a bifurcated, continuous aggregate that meets itself thus

 ,
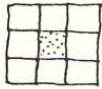
and the double pair form, which historically appears to grow into the one above, and may be logically prior to it:

 .

On a larger scale, it generates the 'green' village and the 'plaza' pueblo. Because they are finite, 'plaza' forms rarely produce towns in the proper sense, but there is a variation on the 5-syntax which does generate towns, because it is the only nonfinite version of the rule. This is where the aggregate breaks into two, and the open disk is then enclosed *between* the two aggregates, and can therefore continue to grow and expand at either end. This is the classic 'long-wide street' morphology, in which the urban form is little more than a single, wide, often long, 'street'. In the many examples of this syntax among English settlements, it is frequently the case that the elongated space is wider in the middle than at the ends, thus emphasising the 5-syntactic form. More interesting, however, is the fact that in a high proportion of such cases the mode of adding further objects is in strips or pairs of strips away from the 'street', with an opening directly onto the street. This is essentially a repetition on a small scale of the same syntactic principle. It expands the global open space into a series of long 'fingers' reaching deep into the areas behind the objects fronting on the main street. In this morphology rings very rarely occur. Bedale, shown in figure 8, while it does possess a single ring, is a good example of this morphology.

The path morphology associated with the 5-syntax is produced by the idea of an aggregate controlling permeability to itself through its enclosed open disk. This has the characteristic form of a 'star'.

Whereas the 5-syntax 'glues together' an aggregate of closed disks by means of an enclosed open disk, the 6-syntax 'binds together' an aggregate of closed disks by means of a closed disk which encloses the aggregate. Among the characteristic morphologies produced by this rule are the modern 'block' and the 'estate'. The associated path morphology is the 'tree' of nontraversing paths (that is a path segment leading to a set of branching segments which themselves have branches, but which are eventually limits) to which in certain realisations we assign the name 'corridors'. Since these relations are far from obvious (6-syntaxes are much less well recognised morphologies than 5-syntaxes) they need to be examined with some care.

First, it should be recalled that the 2-syntactic object was a closed boundary, not a closed disk. The closed disk emerged from the fact that if there had been nothing contained within the closed boundary, it would have degenerated to a simple *d*-object, and no transformation would have taken place. Similarly for the 4-syntax, the second closed boundary contained a ring since, had it not done so and been pressed instead directly onto the closed disk, the transformation would have degenerated into a closed disk again. At the 6-syntactic level, these consequences of pressing a boundary directly onto another no longer arise, since the second boundary is now to enclose an aggregate, one moreover that lacks other internal relations to 'glue' it together.

The second boundary may therefore in principle be pressed directly onto the boundaries of the closed disks it contains. A simple object illustrates this:

This is unlike the 2-syntactic multicellular object in that it has an extra structure defined on it. This extra structure produces the 6-syntactic path morphology, in that a nontraversing path controls permeability to an aggregate (two in this case) of closed disks, giving the elementary branching structure of the 'tree' path form. Less obviously, but we hope no less necessarily, the two closed disks should be seen as being bound together by a complete outer boundary which, in part, is pressed directly onto the boundaries of the closed disk. Formally speaking, this can be justified by a perfect homology of space and path formulae:

$$(\langle d \rangle \supset d) \to \{ (\ )(\ ) ... (\ ) \} ,$$

and

$$(\langle d \rangle \supset d) \supset \{ (\ )(\ ) ... (\ ) \} .$$

Intuitively it can be argued that the lack of internal space structure forces a separate—and therefore nontraversing—path system into existence in order to make the structure permeable. A clear illustration of a 6-syntactic morphology, where an aggregate of closed disks (they have in fact additional internal structure, but this does not concern us in analysing the global morphology) is tightly bound together by a closed boundary and is internally connected by a (slightly imperfect) tree of nontraversing paths, is the "workers' quarter" in El Amarna in ancient Egypt, shown in figure 9.
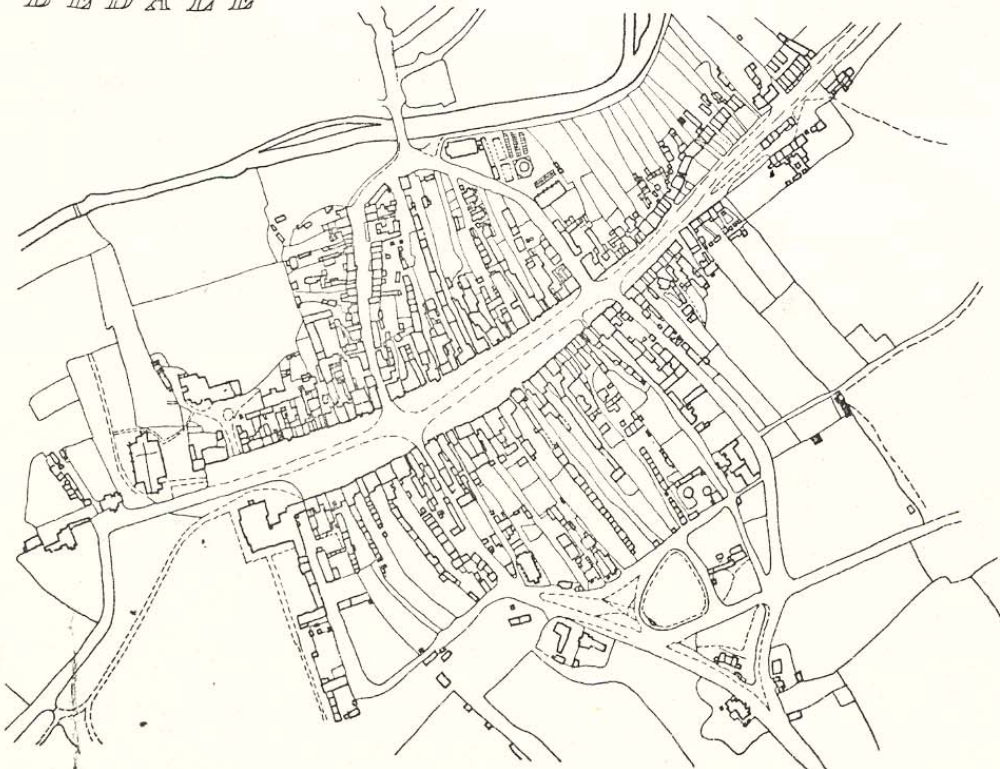

Figure 8. Bedale (after OSC, 1888–1893).

The characteristic forms of 'estate' built increasingly over the past century offer some of the clearest examples of 6-syntactic morphologies, often combining the 6-syntactic version of the block, with the concept of an 'estate', which is a name we give to the closed disk formed by the estate boundary and the space in which the 'blocks' are so carefully 'laid out'. It is clear that no arrangements that leave the two levels of 6-syntax invariant in such a morphology will have any effect on the final syntax of the result. A characteristic example is given in figure 10.

The defining property of the 7-syntax is the *open, enclosed ring* (and its associated path morphology, the traversing ring-path), that is a ring which is enclosed not by its own boundary but by an aggregation of closed disks whose boundaries all belong to them. This requires a split in the aggregate such that one subaggregate is inside the other, and the ring is therefore defined by being between the two. The elementary object already defined interprets this by putting one closed disk between two others, with an open ring surrounding the middle disk. A more developed and lifelike realisation would be given by
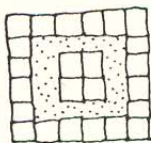
In its elementary unfoldings, the 7-syntax gives rise to the classic, minimal 'ring-street' morphology, which has been a generic settlement form in many parts of the world. Two slightly differing examples are given, one from southern France, the other from northern England, figures 11 and 12.

The most important morphological result of the 7-syntax is, however, the concept of a 'street pattern' strongly separating front and back (unlike the 3-syntax), which is exactly given by the *continuous aggregation of open enclosed rings*. If we take, for example, the case of the somewhat idealised French medieval town (nevertheless a real one), see figure 13, it can be seen that its global description is of a *ring of open enclosed rings containing an open disk*. The way in which the open rings were first constituted (prior to infill of any 'holes') is shown in a plan of the town of medieval Conway, figure 14.

Thus it can be seen that from the foundation a 'street', if it is not the long wide 5-syntactic street form, is only constituted by being part of a street pattern, based on at least one open enclosed ring. If this analysis is correct then it would appear that recent attempts by designers to recreate 'the street' by means of wider 'access decks',
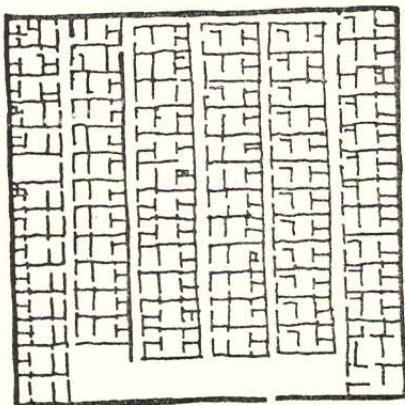

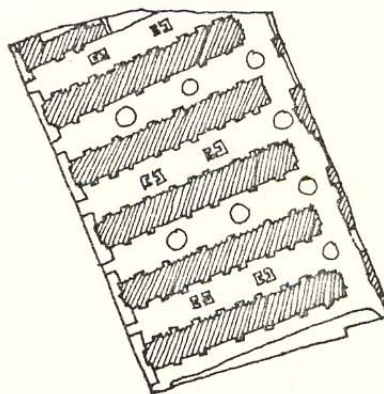Figure 9. El Amarna, workmen's village (after Pete and Woolley, 1923).

Figure 10. Samuel Lewis Trust dwellings (OSC, 1955).

do violence to the syntactic nature of the street form. It would appear that the lay rejection of such improvisations is morphologically correct.

There is another important variant of the 7-syntax, whose identification solves an outstanding problem in the study of settlement evolution. This problem is to explain why the 'pueblo indians' stopped building 'plaza' settlements and began to build settlements consisting of compact lines of dwellings. Reed commented:

"Interpretation of the changes during the last few centuries in the Upper Rio Grande, from the front directed Anasazi plan to the hollow square layout (ubiquitous, apparently, during Pueblo IV) to predominance of parallel alignments, except among the Tewa, is beyond me ... why the linear parallel alignments supersede the unified hollow square in the west, I have no idea" (Reed, 1956, pages 15–16).
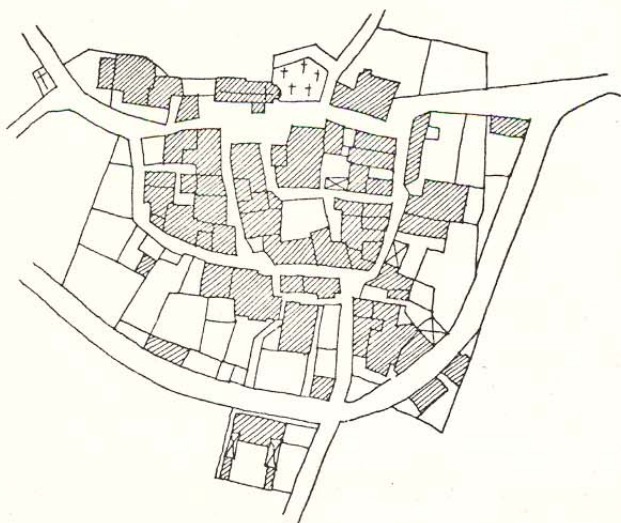

Figure 11. Village of Saint-Trinit (SD, 1934).

Figure 12. Burton in Lonsdale (after OSC, 1883–1893).

The answer is that just as there is a linear version of the 5-syntax, which works by interpreting containment in terms of 'betweenness' rather than 'insideness' (the long wide street form), so there is exactly such a version of the 7-syntax, but involving three lines of aggregated closed disks rather than two. This is easily understood if we return to the 'least object' for 7, which can clearly develop either way. The formula for the 'three line' unfolding, shown in figure 15, is

$$\supset (\langle\!\langle\{(\ )(\ )\ldots(\ )\}\{(\ )(\ )\ldots(\ )\}\rangle\!\rangle \supset \{(\ )(\ )\ldots(\ )\}\rangle \supset (\ )),$$

which can be read: a pair of continuous subaggregates have between them a continuous subaggregate, and the pair formed by the pair of subaggregates and a single subaggregate contains a continuous space (see figure 15). Since neither defence nor climate appear to have any role whatsoever in this transformation, might it not be sufficient to assign syntactic reasons for the change?

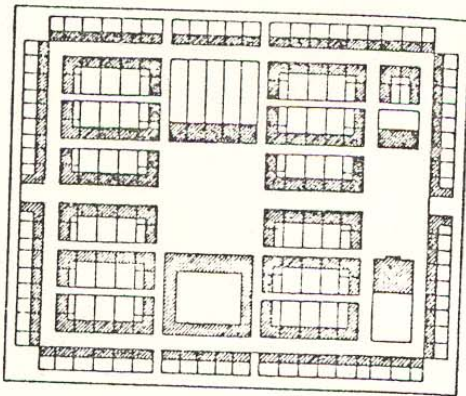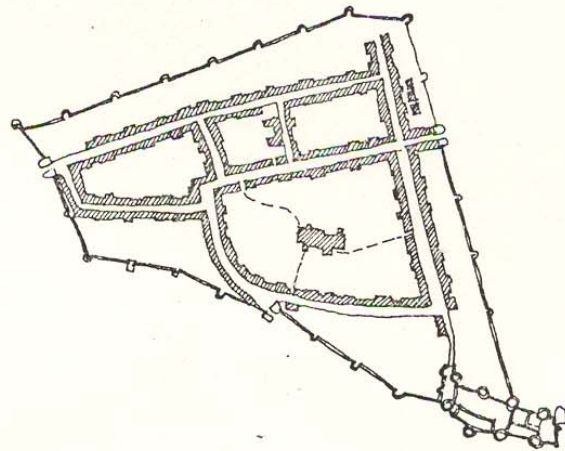**Figure 13.** The New Town of Erlangen, founded by Huguenots (after Gutkind, 1964, page 222).

Figure 14. Medieval Conway (after HMSO, 1957).

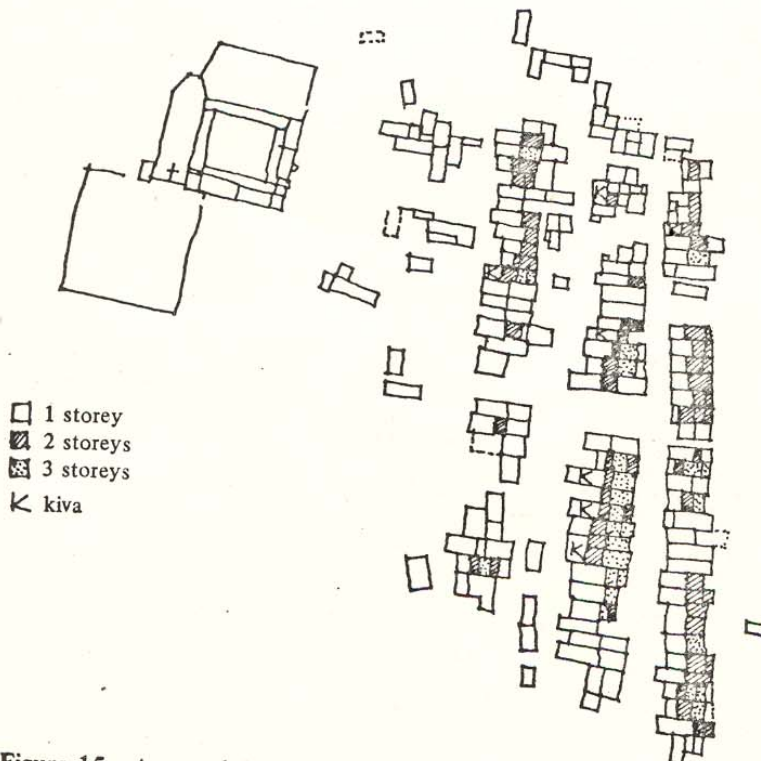
☐ 1 storey
▨ 2 storeys
▩ 3 storeys
Ƙ kiva

Figure 15. Acoma (after Stubbs, 1950, figure 20).

The 7-syntax is the most global distributed syntax (that is each primary cell equally constitutes the predetermined global morphology). The reason why urban form has not progressed beyond the 7-syntactic form but retreated from it is, of course, that there is nothing beyond it. It is all that is possible.

The 8-syntax is the most global nondistributed syntax, and its unfolding locates all primary cells within the inner and outer boundaries of a closed ring, without further internal relations, as in the 6-syntax. An idealised version of a typical object might have the form
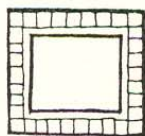
Although interesting examples of this syntax exist in ethnographic records, including, for example, the 'single building settlements form' of the Hakka tribe in China (figure 16), and even the mile wide 'great kraal' of Shaka the Zulu king (figure 17), the most spectacular realisations are modern, or recent. For example, the classic models for prisons in the 'panopticon' era moved from 6-syntaxes to elaborations on the 8-syntax. Take, for example, the design of Bevans (1819), figure 18, which can be described as: a ring of closed rings containing aggregates of closed disks, contains a closed disk. It turns out to be an exact inversion of the 'urban' distributed form described in figure 13. The path morphology associated with the 8-syntax is the nontraversing ring path.
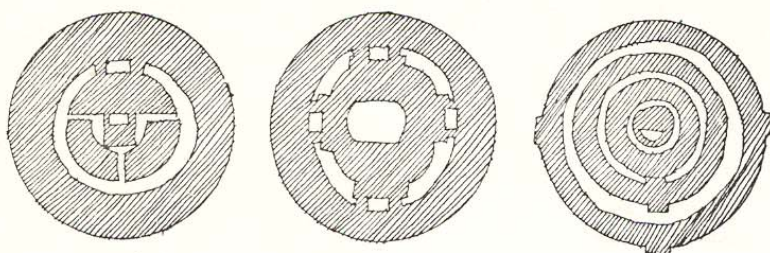

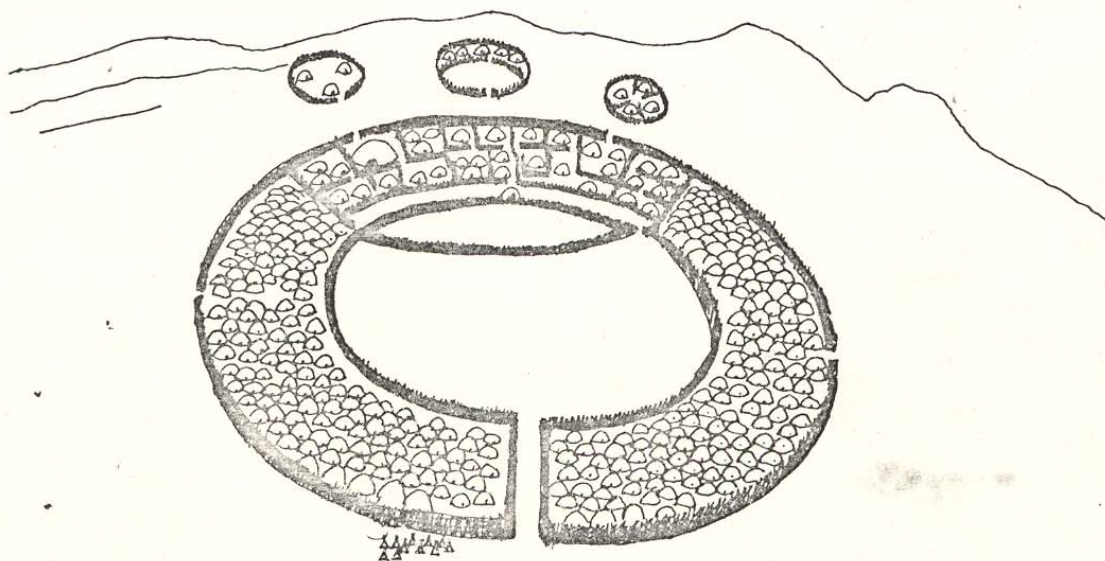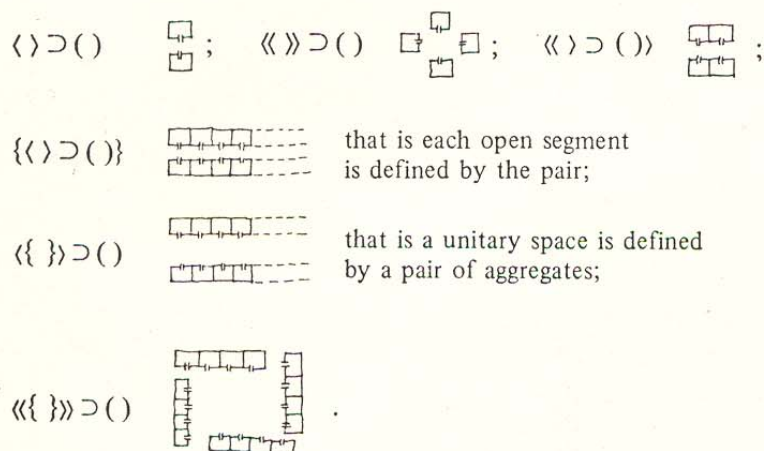Figure 16. Circular plan types of Hakka dwellings (after Boyd, 1962, page 105).

Figure 17. Zulu royal kraal (after Gluckman, 1960).

Figure 19 summarises the eight syntaxes and their principal morphological realisations.

From each syntactic generator a family of related forms can be generated by introducing further bracketing into a formula, while leaving the *defining relation* of the syntax invariant. For example (simplifying formulae for the sake of clarity), all the following are variants in the 5-syntax:

$\langle\,\rangle \supset (\,)$; $\langle\!\langle\,\rangle\!\rangle \supset (\,)$; $\langle\,\rangle \supset (\,)$;

$\{\langle\,\rangle \supset (\,)\}$ that is each open segment is defined by the pair;

$\langle\{\ \}\rangle \supset (\,)$ that is a unitary space is defined by a pair of aggregates;

$\langle\!\langle\{\ \}\rangle\!\rangle \supset (\,)$.

From these it can be seen that an overall rebracketing keeps the form relatively localised, while the 'left only' bracketing requires more closed disks to be related to the open disks, and this increases the degree of global order.

The derivation of a street pattern from the 7-formula follows from a development of the bracketing structure. If we begin from the form $\langle\{\ \} \supset \{\ \}\rangle \supset (\,)$ (as given in the 7-syntactic object shown on page 171), it is not easy to see how the double containing relation (the open ring is between two subaggregates, one of which is inside the other) is retained in a street pattern based on a set of open rings. The growth process is as follows: at least the second of the pairs of aggregates becomes a pair, $\langle\{\ \} \supset \langle\!\langle\{\ \}\rangle\!\rangle \supset (\,)$. (If the first aggregate also becomes a pair, or even a pair of pairs, the essential transformation remains.) The form will then, of necessity, contain a pair of intersecting open rings
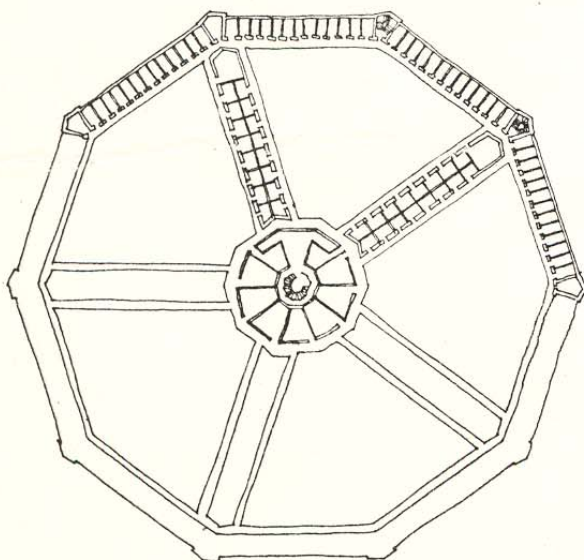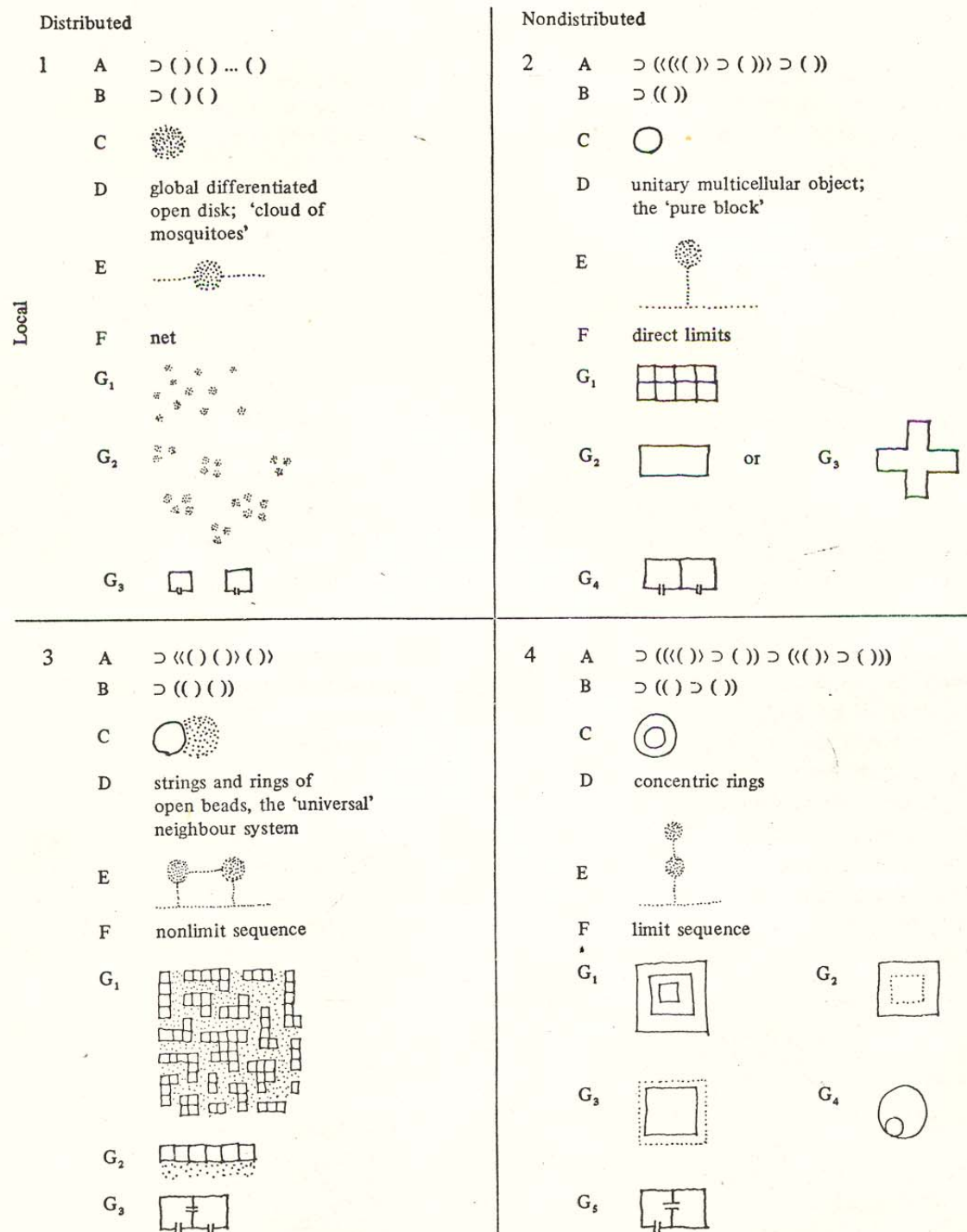

Figure 18. Design for a penitentiary for 600 prisoners (after Bevans, 1819, prisons 3, plate 4).

Distributed

1   A $\supset ()()\ldots()$

    B $\supset ()()$

    C

    D   global differentiated open disk; 'cloud of mosquitoes'

    E

    F   net

    G_1

    G_2

    G_3

Nondistributed

2   A $\supset ((((() \supset ())) \supset ())$

    B $\supset (())$

    C

    D   unitary multicellular object; the 'pure block'

    E

    F   direct limits

    G_1

    G_2 or G_3

    G_4

3   A $\supset ((()()) ()$

    B $\supset (()())$

    C

    D   strings and rings of open beads, the 'universal' neighbour system

    E

    F   nonlimit sequence

    G_1

    G_2

    G_3

4   A $\supset ((((()) \supset ()) \supset ((()) \supset ()))$

    B $\supset (() \supset ())$

    C

    D   concentric rings

    E

    F   limit sequence

    G_1 G_2

    G_3 G_4
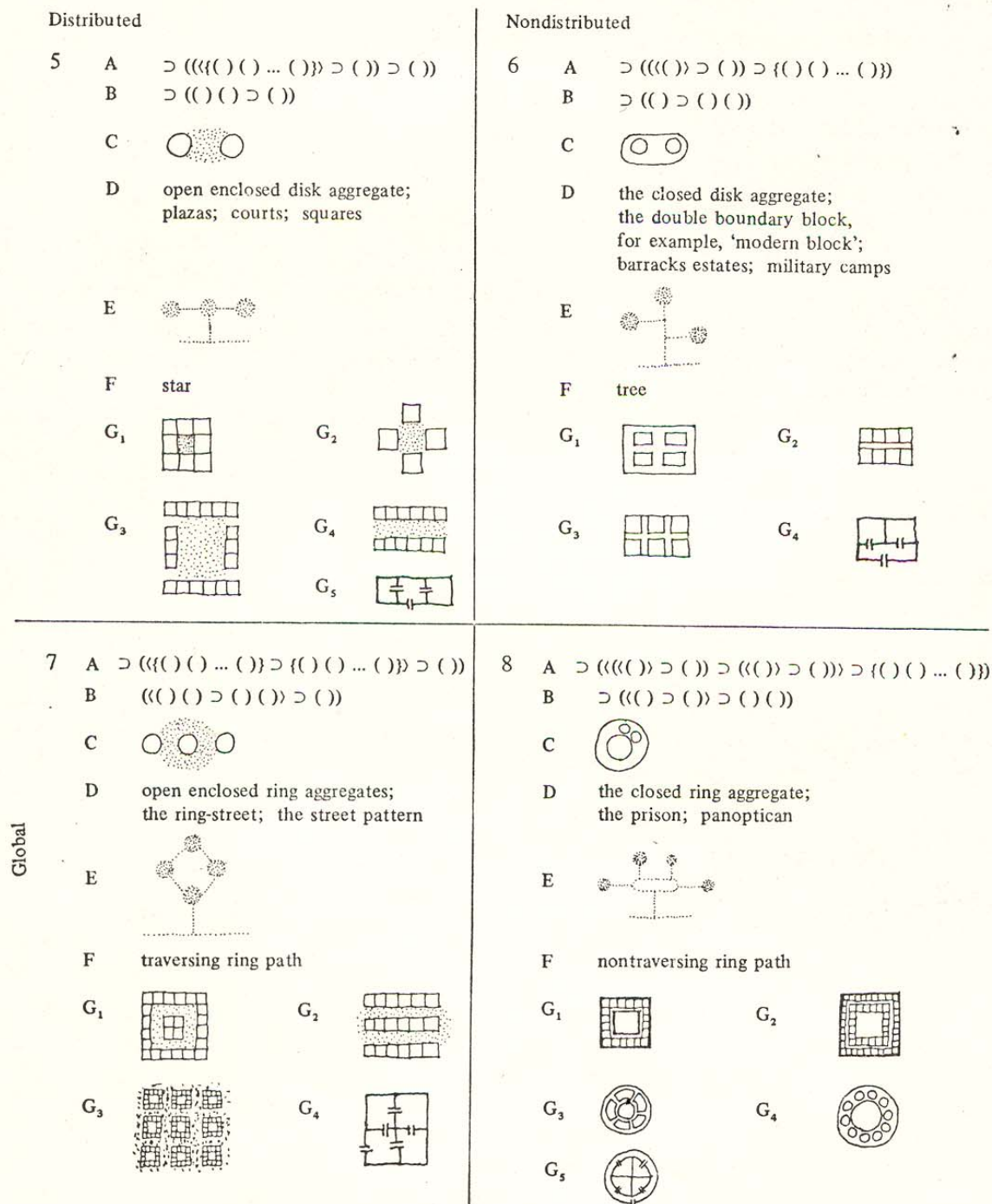
    G_5

Local (left column label)

Key: A, generative formula; B, simplified formula; C, elementary space object; D, global space description; E, elementary path object; F, global path description; G, typical global objects and variants.

Notes:

(a) In all the syntaxes, the final example is the simplest realisation of the syntax for aggregates (that is at least two) of closed disks. All are extant morphologies, with known examples.

(b) *1-syntax*: G_2 repeats the 1-syntax at two levels; the smaller, a local zone, say a dwelling cluster of a minimal lineage; and the larger, the 1-syntax of these local zones in a global zone. *2-syntax*: G_2 and G_3 represent an alternative form of development for a 2-syntactic object; increasing the size of a simple closed disk while retaining the structure of the 2-syntactic object. The two examples are technologically possible ways of carrying out this development. In G_2 the closed disk is stretched 'pairwise'; in G_3 it is stretched 'double pairwise'.

Figure 19. Morphological archetypes.

Distributed | Nondistributed

5 A ⊃ ((({( ) ( ) ... ( )}) ⊃ ( )) ⊃ ( ))
B ⊃ (( ) ( ) ⊃ ( ))

C

D open enclosed disk aggregate;
plazas; courts; squares

E

F star

G₁ G₂

G₃ G₄

G₅

6 A ⊃ ((( )) ⊃ ( )) ⊃ {( ) ( ) ... ( )})
B ⊃ (( ) ⊃ ( ) ( ))

C

D the closed disk aggregate;
the double boundary block,
for example, 'modern block';
barracks estates; military camps

E

F tree

G₁ G₂

G₃ G₄

7 A ⊃ (({( ) ( ) ... ( )} ⊃ {( ) ( ) ... ( )}) ⊃ ( ))
B (( ) ( ) ⊃ ( ) ( )) ⊃ ( ))

C

D open enclosed ring aggregates;
the ring-street; the street pattern

E

F traversing ring path

G₁ G₂

G₃ G₄

8 A ⊃ (((( )) ⊃ ( )) ⊃ (( )) ⊃ ( ))) ⊃ {( ) ( ) ... ( )})
B ⊃ (( ) ⊃ ( )) ⊃ ( ) ( ))

C

D the closed ring aggregate;
the prison; panoptican

E

F nontraversing ring path

G₁ G₂

G₃ G₄

G₅

Global

3-syntax: E, the path morphology results from the dense aggregation of 'through permeable' objects. This implies that eventually there is another way back to the carrier path, hence the concept of a through permeable sequence, or nonlimit sequence. *4-syntax*: G₅ gives the simplest path realisation of the concept of a 'to-permeable' sequence, or limit sequence. *5-syntax*: E, the path morphology is a result of the aggregate controlling permeability to the open-enclosed disk, and thus to the aggregate of closed disks giving the 'star' form, and the 'inward looking' aggregate. *6-syntax*: E, the 'tree' morphology interprets the concept of 'sequence' for a nontraversing path system. *7-syntax*: G₄, the aggregate resembles the 3-syntactic 'nonlimit sequence' but there is a difference. In 7, there is one space that is traversed twice in traversing the whole system, making a complete ring independent of the carrier path. *8-syntax*: G₄, this is drawn without its aggregates of small enclosed disks, because of the complexity of the form.

(c) Path forms here are related by formula analogy to the space forms. A parallel theory of path morphology is in preparation which is somewhat richer.

Figure 19 (continued)

as the unitary structure on the right of the formula,
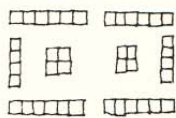
Two clear realisations of this unfolding are 17th century Hertford and Peterborough (figures 20 and 21). It can be seen that this procedure may be followed to generate any number of intersecting open rings.

Some interesting observations on the syntactic nature of streets can be offered at this point. It can be seen that although a street is only a street by virtue of its membership of a street pattern with the minimum form of a simple open ring, at the same time each street in a sufficiently rich setup is itself the unique intersection of a pair of open rings. This means that each ring differentiates naturally into four segments with a unique set of local syntactic relations. This seems a reasonable formal approximation of an essential intuitive property of a street: that it is uniquely differentiated syntactically while being continuously connected to a continuous structure of open space. Thus a street is not simply a certain kind of enclosure. It is a local differentiation of a continuous space structure with, characteristically, four ways out, which fully connect each street into its constitutive open rings. The same applies to a 'market place', which is the intersection of a pair of pairs of open rings, or a set of open rings. The 'square' is as natural in the unfolding of a 7-syntax as the 'bead' is in the 3-syntax.
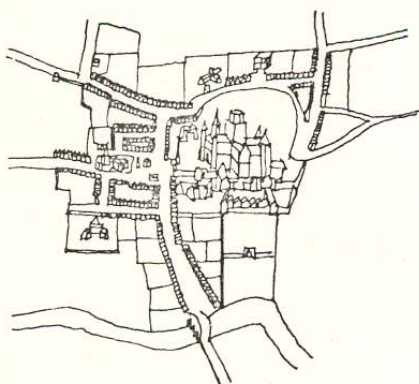

Figure 20. Early 17th century Peterborough (after Speed, 1974, plate XXIX, figure 105).
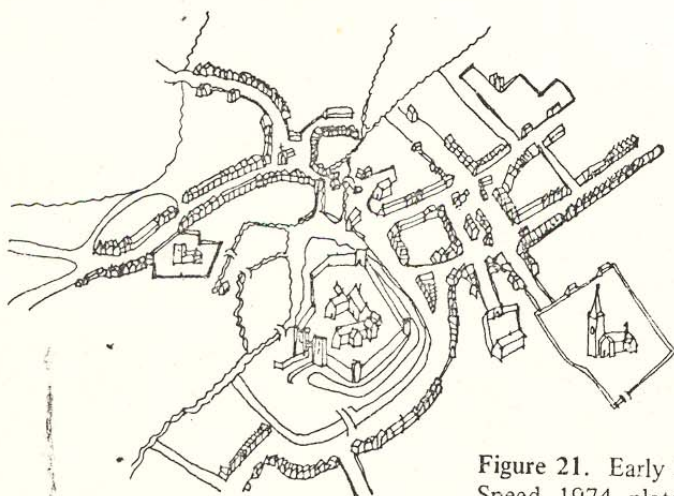

Figure 21. Early 17th century Hertford (after Speed, 1974, plate XXXI, figure 110).

4 Space and society

It may be objected that in giving this syntactic and largely abstract account of a theory of the formation of settlements and architectural complexes, we have ignored the customary lines of enquiry which seek to establish particular historical, economic, or geographical 'causes' for particular patterns, or particular cases. It is not out of disrespect for this considerable body of work that we have, while assiduously analysing the existing record of real examples, temporarily adopted a resolutely abstract point of view. It is because of the widely acknowledged failure of descriptive and analytic work to reveal significant associations and relationships. We therefore took the view that until we knew what a settlement pattern was, and in what their essential similarities and differences consisted, it was futile to pursue causal explanations. We took the advice of Hermann Weyl:

"The experience of science accumulated in her own history has led to the recognition that evolution is far from being the basic principle of world understanding; it is the end rather than the beginning of an analysis of nature. Explanation of a phenomenon is not to be sought in its origin but in its immanent law. Knowledge of the laws and of the inner constitution of things must be far advanced before one may hope to understand or hypothetically to reconstruct their genesis" (Weyl, 1963, page 286).

This is in our view clearly true in the study of the social production of architectural and settlement form. It is clear that in order to understand any particular example one needs to know two things: a particular set of historical determinants and contingencies; and the 'immanent laws' of the constitution of spatial structure itself. Our hope is that with at least a theory of the 'immanent laws' the empirical study of built form may be reinvigorated and perhaps to some extent more aptly directed. This anyway was the limit of our hopes when embarking on the development of the model by the careful analysis of the record.

However, as the model became better and better defined, it became clear that it might also be possible to associate with the space syntax model a social theory of the production and use of space patterns, by using similar concepts and methods to describe society as we had used to describe space. Almost as soon as this was attempted a clear, if somewhat complex, 'inverse law' began to suggest itself as the relation between social and spatial structure. Furthermore, the theory as we developed it appeared to make sense and relate a significant proportion of the conclusions of other researchers, including architectural researchers, anthropologists, and even an economic anthropologist. Although it is in no sense a tested theory yet, having been developed and applied only retrospectively to the evidence collected by others, we are satisfied that the match between the formal structure of the theory and the distribution of evidence as currently known is sufficiently suggestive and exact to permit our giving an account of it at this premature stage. Unfortunately, in the time so far available, it has not been possible to give a thorough review and reference to the work of others on which we draw. This serious deficiency will of course be corrected in a later paper.

This theory does not have a 'causal' form. It does not argue that particular forms of society 'cause' particular kinds of space patterns. Space is not a result of society as much as one of the means by which the social is constituted and made real. The theory is more in the form of *pattern similarities or relationships between spatial and social syntax*—social syntax being the patterns of encounters and relationships that hold among the members of a society. Nor is it correct to seek in such patterns and comparisons only a spatial *reflection* of social form. In certain cases space is a reflection, but more usually it is an *alleviation* of, or *means to*, or even a *substitute*

for social organisation. *Space is not a reflection of society, but a set of strategies in relation to social form, as often as not offering an alternative basis for encounters, other than those dictated by the social structure.* The streets of the city, for example, do not always reflect the social structure; they can be the means by which the pattern of social differences is forgotten, and the inhomogeneous is assembled. They constitute the profane mixing of categories which in the social structure are separate and insulated from each other.

In extending the concept of 'syntax' to social relationships and encounters, it must, of course, be stressed that no such syntactic theory yet exists on a level of exactness comparable to the syntax theory of space. On the other hand, the theoretical ideas and descriptive work of certain anthropologists and sociologists is certainly responsive to such an interpretation. At a broad level, we shall try to show that both the general shape of the syntax model as a whole, and the patterns implied by particular syntaxes, provide useful ways of talking about social relationships. Before embarking on this, however, it is necessary to clarify exactly what the general shape of the syntax model is. For the following discussion, the reader is referred to figure 19.

The two columns divide the syntaxes into first, the *distributed*, or *glued together*, and second, the *nondistributed*, or *bound together*. In *distributed* syntaxes whatever space structure exists there is equally constituted by each primary cell. These are given odd numbers, and the higher the number the more the syntax requires a global spatial rule (dominating the local placings) for its realisation. In *nondistributed* syntaxes the space structure is the result of an increasingly complex system of boundaries or spaces surrounding cells. These are given even numbers, and in the most local case the boundary simply encloses a continuous space, whereas in the high numbered more global cases boundary structures dominate the primary cells. In distributed syntaxes the integrating entity is always *inside* the collection of primary cells, and in some sense contained by them; in nondistributed syntaxes the integrating entity is *outside* the primary cells, and in some sense contains them.

Translated into social terms, a social order based on the *division of labour* (such as existed before the industrial revolution separated the skilled worker from his tools), in which each individual participates in society primarily through his functional interdependence with individuals possessing other specialities, is a concept which is both *local* and *distributed*. The global order arises out of a local ordering, that is, a pattern in which a particular individual repeatedly does a particular job. By contrast, the form of society that usually precedes this is that based on an elaborate and ritualised kinship system, usually involving a system of extensive naming of segments that are essentially similar (that is they all carry out the same functions). This is a *globally* ordered *distributed* system. The system still depends on being continuously recreated by the action of individuals, but these are controlled by a previously established global model. The global model in no way *arises* from the local actions; rather the latter conforms to the former. The former kind of society we could call 'urban', and the latter 'tribal'.

These two forms of society were called 'organically solid' (division of labour) and 'mechanically solid' (kinship) by the sociologist Émile Durkheim (1933). The latter form depends on a model which is not only global, but also symbolic; whereas the former depends on a model which is both local and instrumental—that is, it depends on real work as opposed to symbolic work. Also the former depends on real differences between people, whereas the latter depends on differences introduced by naming. For this reason, kin-based societies are sometimes known as 'segmental' because they are made up of large numbers of virtually identical segments.

These two polar types of social pattern appear to be *inversely related* to their corresponding spatial models on the local–global dimension, but *directly related* on

the distributed–nondistributed dimension. According to the American anthropologist, Elman Service, the ritualisation of kinship systems as a basis for social solidarity · increases as the basic settlement units become more dispersed (Service, 1971), that is, at the 1-syntactic level. The less space physically integrates the society, the more integration depends on a global social model of a nonphysical (that is symbolic) kind[6].

Exactly the opposite is true for the 'division of labour' form of traditional urban social solidarity. The theatre in which the division of labour (the local-to-global distributed social model) develops is the physically integrated space of the urban street pattern (that is, the global distributed model of space based on the 7-syntax). At the same time, the spatial model is physical, as opposed to symbolic, corresponding to the transition from kinship to the division of labour itself. From this follows the frequently observed association between the transition from kin-based to space-based society, and the transition from segmental work patterns to the division of labour.

In each of these polar cases, space plays an *inverse* role to the social structure. It is almost as though, at the 1-syntactic level, space provides a means of escape from the homogeneous social pattern (Sahlins, 1974), whereas at the 7-syntactic level, it integrates what has become socially differentiated. In both cases space alleviates social structure rather than reflecting it, yet is nonetheless systematically related to it.

The 3- and 5-syntaxes on the other hand, have more closely parallel relationships between social and spatial structure, though in different ways. The 3-syntax, in which the global spatial pattern arises from local and distributed actions, corresponds to a social pattern which it formally resembles. This is the form of small scale, distributed societies characterised by Bailey (1972) as 'multiplex'. In brief, these are small spatially integrated societies in which each person is likely to know and encounter each other person for several different reasons. For example, the same person may be encountered as someone who serves you in a shop, whom you meet in a public house, who is your cousin, and who repairs your car in his spare time. Such encounter patterns are 'multiplex' in contrast to the type of encounter pattern generated by modern 'estates', where most encounters are specialised and not reduplicated in other areas of life. The theory is that 'multiplex' encounter patterns involve the 'whole person' in continuous confrontations and, as a result, 'reputation' becomes of vital importance—and much social life is concerned with the negotiation and renegotiation of reputations. An unfortunate encounter in one domain of life will reverberate through all others and affect the whole 'reputation' of the person.

Like kinship patterns, the pattern of 'reputations' is still a symbolic reality, but it is no longer determined by some preestablished global model. It is continuously constructed by the negotiation of individuals. The global 'reputation pattern' at any particular time *is* constitutive of the social for that society, but it has been arrived at and is about to be changed by a collection of distributed local actions. This fluid, but strong, pattern is the same both for social and spatial patterns, except that the physical integration of space has accompanied the descent from a global to a local symbolic order. This is fully consistent with the overall pattern of development from kinship to urban societies.

A settlement in 5-syntactic form—buildings grouped around a central space—is usually taken to be a case where the spatial form 'reflects' the social form in some sense. In our terms, a correspondence would be held to exist between a global and distributed spatial form, and a global and distributed social form. Researches that

[6] This is reflected in two dominant space-codes in our society. In general the middle class have aspatial networks, and relationships are constituted by patterns of ceremonial occasions, in particular, inviting people to dinner. The traditional working class, by contrast, have strongly spatial (local) networks with much freer general access to dwellings, but a tacit prohibition at mealtime, which is a private occasion.

exist on these societies do not support such a conclusion. Levi-Strauss (1972), for example, hints that the spatial form can be almost a disguise for the real social structure. It represents a unity and simplicity of organisation, which is not possessed by the social structure itself. In such cases it might be argued that the settlement pattern *represents* the society, but does not reflect its structure. Again this is consistent with the basic theoretical shift. Space increasingly provides an alternative basis in everyday life for a social structure whose complexities cannot be sustained in everyday practical life. Such settlements appear to be characterised by strong spatial and temporal categorisations of sacred and profane, and a tendency for these categorisations to play an important role in everyday and ritualistic life.

The nondistributed syntaxes exhibit virtually the opposite movement. The simplest nondistributed spatial gesture, the creation of a closed cell by means of a boundary (the 2-syntax), *established a domain of nondistributed spatial control within which the social takes precedence over the spatial*. If this is thought of at the level of the individual and his boundary (for example, a room) then we have something close to 'territorial' behaviour. Within the boundary, a social, local, and nondistributed—but in all events strong—social model prevails. This is as true of the individual with his guest in the room, as of the open-plan factory, the open-plan school, the church, and the football field.

At the other extreme the 8-syntax; although a global, nondistributed boundary system maximally controls the primary space, the spatial form totally dominates the social form and acts as a substitute for it. A prison is not simply about spatial control. It is about the elimination of social structure by the segregation of individuals (three to a room is a defect in reality, not in the theory!). A prison substitutes a globally defined, locally dominant, nondistributed spatial order for lateral social structure. A prison is a large, but essentially simple, social organisation. Its only social form is simple hierarchy (officially, that is—but this is why all films about prison life are centred around the prisoners' self-generated, informal social organisation). Otherwise it has become homogeneous and segmented with the individual in his cell as the ultimate segment.

The 6-syntactic urban landscape of today is a milder form, but along the same lines: increasingly a spatial order is substituted for a social order, and this social order becomes a set of homogeneous, separate segments called nuclear families, with very strong sanction against the extension of social complexity even in the direction of a slightly extended family. Every activity has its own spatial boundary, and, correspondingly, social encounters are highly specific, rarely multiplex. Both space and encounter patterns are dominated by nondistributed agencies known as bureaucracies. Social life, other than that represented in the set of bounded locations permitted by the space pattern, is deterred both by the social and by the spatial pattern. The problem with this syntax is that it *does* reflect society. Indeed, its coerciveness is in no small part owed to the similarity of social and spatial syntax, which constantly reinforce each other to the point of appearing natural.

The remaining nondistributed syntax, the 4-syntax, is the other primary form of spatial order in the modern English landscape: the suburb. This is a local, non-distributed ordering based on a primary cell with a double boundary within which symbolic objects are placed (wishing wells, sundials, flowers) which express individual participation in a symbolic social order.

Syntaxes 3 and 6, and 4 and 5 have an interesting set of mirror relations. If 3 and 6 reflect social order, 4 and 5 appear to *misrepresent* it. Syntax 5 represents a simple global model of society, simpler than the social structure and perhaps more mythical than real. Conversely, syntax 4 represents an act of individual separation from

society, which is again mythical. The spatial gesture of the suburb, with all its powerful sanctions to conform to an established pattern, sets up a myth of individual freedom and difference around an act of conformity and consensus.

These arguments may be summarised in the following general propositions:

(a) at the lowest syntactic level, distributed *space is a means of escape* from the social;

(b) and at this level, nondistributed space constitutes a minimal domain within which the *social prevails over the spatial*;

(c) in general, both for distributed and for nondistributed syntaxes, *space increasingly becomes an alternative basis for the social*, but

(d) if distributed, the higher-number syntaxes put together in space what is socially differentiated;

(e) and if nondistributed, they separate what is socially the same, substituting a spatial regime for a social; and in general

(f) distributed forms constitute an alternative socialness in spite of social inhomogeneity (for example, the relation between the integration of urban space and the division of labour);

(g) and nondistributed forms substitute spatial control for social complexity and inhomogeneity; at the broadest level

(h) low-numbered distributed syntaxes are associated with socialities which are small and homogeneous; low-numbered nondistributed syntaxes with social organization that is small and internally complex; high-numbered distributed syntaxes with societies that are large and complex (that is inhomogenous); and high-numbered nondistributed syntaxes with social forms that are large and simple, that is, both segmental and hierarchical, but lacking complex relations among members.

5 The analysis of real domains

These broad relationships serve as a useful backcloth to the analysis of real sociospatial patterns, but they are only a stepping-stone to the methodology we need to deal with spatial *processes* and *transformations*. Perhaps paradoxically it is at this point that the problem of *description* must be revived in relation to processes of real domain constructions.

A real domain is a $\supset$ relation, or a set of such relations, to a carrier space. A subdomain is a domain whose carrier space is itself a domain. A real domain may be, or become, a stronger or weaker realisation of a certain syntactic type. For example, if the subdomains constructing a street pattern are progressively replaced by blocks of subdomains controlled by a single entrance, then the domain relations of the street (or 7-syntax) are progressively removed, and the domain becomes more and more weakly a 7-domain. This corresponds to an intuitive effect that is usually explained in terms of 'scale' but which, as with many other 'scale' effects, is quite naturally explained as a syntactic effect.

Any domain at any scale (from a simple house to a settlement pattern) is constructed by a process which articulates two kinds of syntactic structure: the *transformation* structure, which gives the nature of units; and the *combinational* structure, which relates each unit to other units. A domain may have k such *interfaces*, that is $k+1$ levels of syntactic organisation. These interfaces, rather than the levels taken 'independently', appear to be the key to the transformational analysis of real domains that are not characterised by a simple syntactic process. In most cases one interface in a process will be more important than others, and will be called the *dominant interface*.

To begin with we may use the notions of description and description retrieval to distinguish *natural* and *unnatural* domain-processes. An unnatural process is one in

which a description retrieval has intervened to introduce more global order into the process. For example, a 3-syntactic aggregate will sooner or later generate an asymmetrical open ring, whose description may be retrieved and introduced as a global order for the next stage of growth. Exactly such a process would constitute a minimal town in which the 'market place' was constituted by the intersection of the pair of open rings. A natural process is one in which description retrieval does not intervene to increase the level of order, although there exist natural processes which also produce more syntactic order as the aggregate grows large[7].

In general as a domain grows it poses problems of description retrieval, which are essentially problems of control, and which normally require more global thinking (that is, conscious design) for their solution. In fact, contrary to current romantic theories of the vernacular, conscious design intervenes in almost all aggregates above a certain small size. In particular, two kinds of description retrieval problems are critical: those concerning the *relations between social and spatial organisation*; and those concerning the *relations across the dominant interface*, that is, between *transformation* and *combination* structures of subdomain and domain.

An apparent general property of domain processes concerns all of these: *the larger a compact spatial aggregate becomes, the stronger must be the social structure which relates it to comparable aggregates across the carrier space.* The converse of this is a general proposition, argued by Sahlins (1974), that spatial fission occurs in the 'state of nature' to avoid the construction of an overstrong social structure.

To illustrate the proposition itself, we may refer to recent work by Bradfield (1973). Among the Tallensi, the compact aggregates are small, familial compounds which never grow above a certain size. In such a case, a relatively weak social structure is adequate at the combination level, consisting more of symbolic and ritualistic arrangements than explicit sanctions. The villages of the Mende, on the other hand, where the compact aggregate is much larger, have much stronger secret societies (which Bradfield suspects may have to do with the emergence of social classes) which operate largely at the level of relations between villages. When considering towns, this development reaches a new level. The exigencies of relationships between settlements are such as to transform the within-settlement social structure into the embryonic form of a class structure.

It may be speculated, on the basis of this proposition, that tribal and urban societies are not, after all, stages on the same evolutionary pathway, but divergent sociospatial processes which occur from the beginning of agriculture. Tribal forms are essentially based on distributed, noncompact, noncontiguous syntaxes[8], with space in a largely symbolic role, and social structures constructed on a symbolic basis without strong sanctions. The nondistributed version would be tribal conquest systems, in which an instrumental order of man-to-man relations predominate over an expressive order, and nondistributed settlements control a large landscape (see, for example, the Zulu kraal in figure 17). Urban societies are essentially based on the primacy of man-to-nature relations, the division of labour, the compacting of space, and consequent increase in the strength of a sanctions-based social order (Park, 1974). The earliest distributed versions of this are in ancient Mesopotamia and the nondistributed versions are in pre-Columbian America, for example, the Aztecs[9].

[7] These processes are the subject of a forthcoming programme of computer experiments.
[8] Current theory suggests that there may exist a mirror set of *negative syntaxes* which are, in essence, syntax theory interpreted for point arrangements, and which may be called 'negative' by analogy with negative numbers, with the first syntax as the 'zero' of positive and negative syntax.
[9] An as yet unpublished study of this theme has been undertaken by Ross Donaldson at School of Environmental Studies, University College London.

Against this background, it would perhaps be useful to reconsider feudalism as a sociospatial form, with particular attention to the dominant interface.

These are preliminary considerations, however. The only justification for including them in the paper is to show the potential usefulness of both a formal approach and a sociospatial framework to the analysis of social as well as spatial forms.

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