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BRIDGING CONFIGURATIONAL AND URBAN TISSUE ANALYSIS

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ABSTRACT

The paper reports on theoretical research building on the work of Steadman, Marshall and others that examines in detail the basis for correlating the outputs of configurational analysis and urban tissue analysis. The aim of the research is to raise the yield of analysis when combining configurational and typo-morphological methods. A broader, overarching aim is to establish a bridge between the two different approaches to urban morphology that facilitates communication and helps to develop a more comprehensive and coherent set of concepts for understanding the structure and dynamics of the built environment.

KEYWORDS

Urban tissue, configuration, generic structure, correlation, comparison

1. INTRODUCTION AND METHODS

There is a growing body of research and practice that brings together concepts and methods from distinct approaches to urban morphology (Griffiths 2015; Lim 2015; Kropf 2009, 2014c; Marcus 2005; Osmond 2006, 2010; Oliveira 2015a, 2015b; Vialard 2015). Underpinning these efforts is an explicit or tacit acknowledgement that urban from is multi-faceted and that combining different descriptions might provide are better result than any one on its own (Kropf 2009). As argued by Bateson (1980), a strong cognitive justification for this view is the principle that operates in binocular vision to produce depth perception. The brain's comparison of two views of the same scene gives an informational yield or bonus. The quality and quantity of the yield is dependent, however, on image rectification and overcoming any correspondence problems. This raises the question, what is the basis for rectifying the descriptions generated by different methods of urban morphological analysis?

This paper reports on theoretical research that examines in detail the basis for rectifying the inputs and outputs of configurational analysis and urban tissue analysis with the aim of raising the yield when combining the two methods. The focus of the research is therefore not on identifying new measures or descriptions but the relations between established descriptive methods. The prudent conclusion is that the common element of the structured space offers a rigorous basis for rectification. It is for further research to explore more fully the more detailed relations that might realise the full potential yield of comparison.

The research has been undertaken using critical analysis and descriptive, logical-relational methods working through iterations of hypothesis, deductive analysis and inductive testing. The principal criteria for judging the results are: consistency, specificity, generality, comprehension and coherence. Important precursors to the research are set out in Kropf 2008, 2009 and 2014a. The root sources for the research include Steadman 1983 , Hillier and Hanson 1984, Hillier 1996, Caniggia and Maffei 2001, Conzen 1969, Moudon 1986, Petruccioli 2007 and Marshall 2004.

The paper will focus on results that show:

1. Primitive elements combine to form a multi-level generic structure of built form
2. Configurational and urban tissue analysis examine two distinct dimensions of that generic structure and can be clearly correlated within it
3. Distinct types of route aggregate can be identified at different levels in the generic structure
4. Route aggregates forming distinct types of sub-system correspond to the level of urban tissue in the multi-level generic structure.

In summary there is a 'structural overlap' or common element used in both configurational and urban tissue analysis. The configurational approach provides a basis for identifying types of route structure. The typo-morphological approach uses types of route structure in identifying types of urban tissue. In turn, the configurational approach undertakes measures of the route structures to establish the characteristics of different configurations. With the 'structural overlap' it is then possible to accurately combine the results of the different methods. The combination and comparison of the two provides a yield of additional information and insight that helps to improve our understanding of urban form.

2. THE FOUNDATION OF MINIMUM ELEMENTS

As in other fields of morphology, one of the starting points for achieving the aims of better communication and the growth of understanding is to identify the **minimum elements** that constitute the phenomena, expressed as generalized, abstract entities. The task is then to identify the ways in which the elements are combined to account for the diversity and complexity of specific forms.

The method of identifying the minimum elements most consistent with the morphological focus on process is to take a developmental approach. From this perspective, the question becomes, from what has built form been derived and what is the minimum set of pertinent features we need to describe the primitive elements?

The starting point is **human activity** in an **environment**.

The features of the environment pertinent to the structure of built form are essentially those of three dimensional geometry and the laws of gravity and mechanics. In terms of a geometric description of built form, the most fundamental morphological element is thus a **surface** on which activity can take place.

There are three fundamental modes of activity rooted in the human diurnal cycle and the need to move through the environment for resources:

- long distance movement
- local activity
- sleep

These modes lead to three **primitive types of surface** in terms of shape, size and relative position:

- tracks
- core territory
- shelter

A surface implies a space. At its most primitive the surface and the implied space are defined not by any constructed boundary but by the extent of an activity and any traces it might leave: footprints and the **difference** between trodden and untrodden ground.

The difference constitutes a **boundary**. However diffuse or well delineated, any distinct space must have a boundary. Spaces are **codependent** with their boundaries.

Boundaries might thus be:

- implied (corresponding to the limits of an activity taking place)
- left (traces or marks left by an activity)
- found (existing boundaries adapted for an activity)
- constructed (including as implied by boundaries of control)

Whatever the nature of the boundary, all three types of primitive bounded surface - tracks, core territory and shelter - can be considered **structured spaces** or **voids**.

Deliberately creating a boundary to form a space involves the selection, manipulation and arrangement of **materials** from the environment to create **physical structures**.

The extent to which any given type of space is defined by physical structures is variable. There is a continuum from the simple **environment**, which would be land uninhabited and unstructured by humans on the one hand and the fully **built environment** of a city on the other. In between is the **proto-built environment**, which is made up of the unconstructed, emergent forms that are implied, left and/or found and not deliberately built. Nor is it necessarily the case that all elements are defined by physical structures to the same extent at a given time. It is worth reinforcing, however, that the proto-built environment, for example prehistoric trackways, is the context in which the built environment has emerged.

When constituted by built structures, the three types of void can be referred to as:

- street spaces
- open areas (defined external spaces)
- rooms.

These terms should be interpreted as broadly as possible to allow for a wide range of specific forms. For example, street spaces include piazzas as well as urban throughways; open areas include front and back gardens as well as campus environments; rooms include habitable spaces, corridors and stairs as well as service spaces such as ducts, flues and cupboards.

Once there is an upright structure enclosing a space, an essential component for these elements to function is an **opening** to allow for movement in and out and from one to another. **Access** and **movement** are therefore fundamental to the structure of built form.

An access point establishes an **internal orientation** for a structured space which in turn forms the basis for the ways in which structured spaces can be combined.

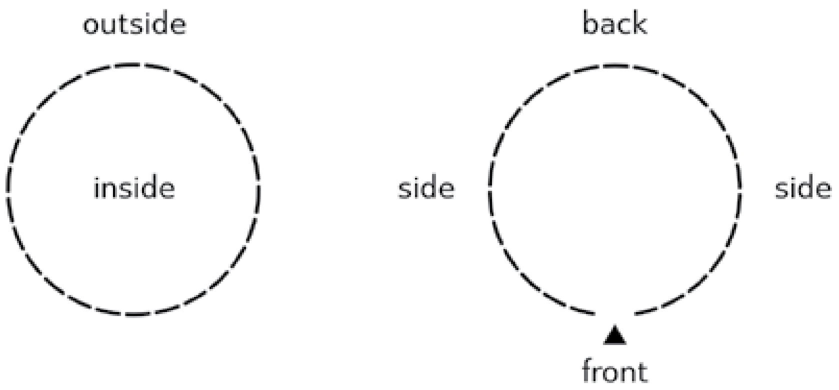


Figure 1 - Simple structured space and structured space with an opening, showing internal orientation

Colloquially, the faces established are

- front
- sides
- back.

There are also different types of opening.

- doors
- vents
- windows.

The inclusion of vents and windows adds further considerations, limits and conditions to the ways structured spaces can be combined. For the purposes of establishing the minimum elements, the only necessary type is an opening that allows physical access.

The three minimum elements of the built environment are therefore:

- surfaces
- boundaries
- openings.

The **number of openings** establishes distinct types of structured space in terms of access. At a minimum there are three access types: single, double and multiple (three or more).

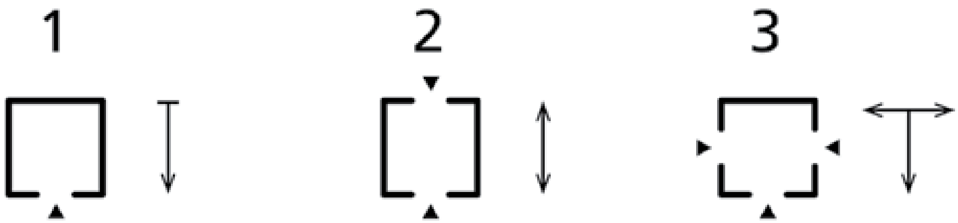


Figure 2 - Access types of structured space based on the number of openings

Each access type has a particular role within a configuration as a whole in terms of the potential range of generic functions it can accommodate.

- Occupation
- Through movement
- Distribution.

These are, of course, not mutually exclusive. Above a minimum size, all spaces can be used for occupation and also accommodate local movement. Distribution is a subset of through movement that allows for greater **choice**. The three access types apply to all three types of void: street spaces, open areas and rooms. The access types also form the basis for possible combinations of two or more structured spaces.

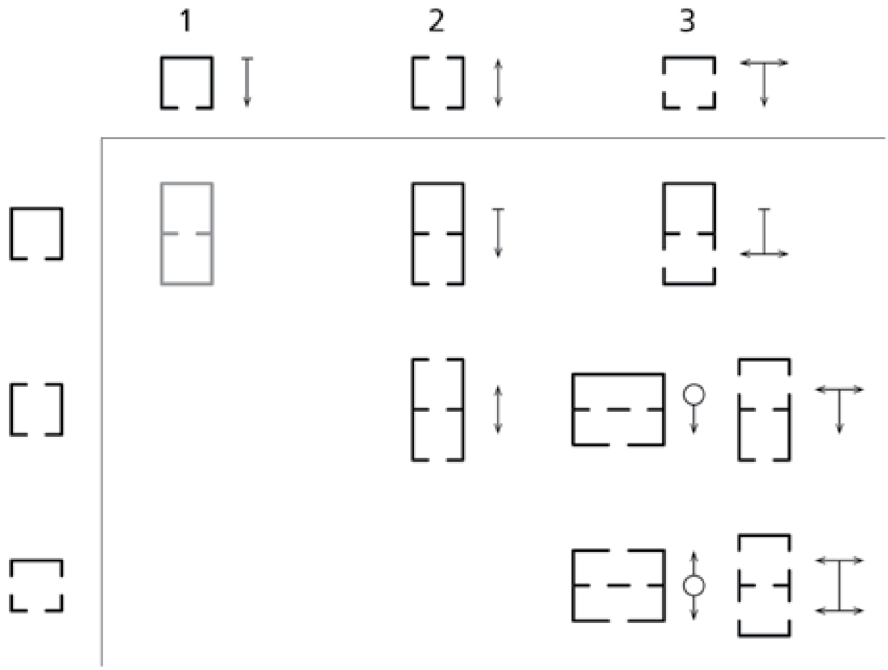


Figure 3 - Possible combinations of the three access types

The structured space diagram assumes a number of graphic conventions. The boundary represents the **plan outline** of the form on the ground plane (the reference surface). The outline assumes and refers to all the physical structures and voids within the outline in all their three dimensional detail both above and below the ground plane. Gaps in the outline and triangles represent access points.

Analytical views

The basic **outline diagram** is in effect an abstract **analytical view** that isolates the minimum elements of surface, boundary and opening. Because the diagram abstracts and combines only the three minimum elements it can be used to represent all different kinds of simple and complex structured space.

An important consequence of using the outline diagram to render all three types of void is that all parts of the built environment can be **positively** represented. That is to say, there is no 'negative' space within the built environment. A street space or open space within a plot is not leftover space between buildings but a positively structured surface. Any given surface is thus either inside or outside the built environment. Put another way, the only 'negative' spaces are those outside the built environment.

The fact that the outline diagram can be used to represent both simple and complex forms suggests that the abstract structured space is the **minimum unit of urban morphological analysis**. The three types of primitive bounded surface can be distinguished as **base structured spaces** and all, more complex forms can then be described as aggregations of the base structured spaces. Because any aggregation is in turn itself a structured space, the underlying process that leads from the base structured spaces to more complex forms can be seen as one of **recursive acts of aggregation**. The result of the process is a **compositional hierarchy of built form**, illustrated in Figure 4. as **a multi-level diagram**.

As set out in Kropf (2009), the multi-level structure necessarily involves the principle of co-extensive elements. In particular, the open areas and street spaces are co-extensive, functioning at two or more levels at once.

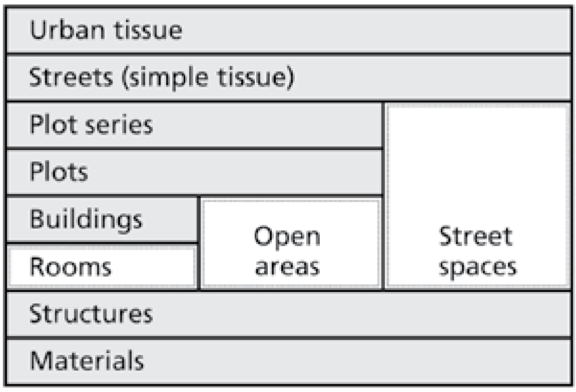
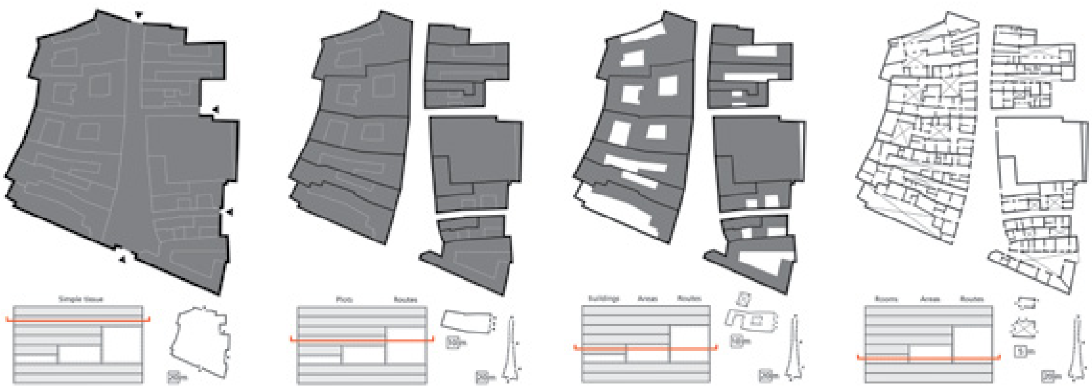


Figure 4 - The multi-level diagram representing the generic structure of built form

The compositional hierarchy represents the **generic structure of built form**. The analytical view of the multi-level diagram is in effect a kind of cross-section through the generic structure. The diagram extrudes out and exposes the different levels of order within urban tissue. The levels in the hierarchy and diagram correspond to **levels of complexity**.

A further, and likely the most familiar analytical view essential to morphological analysis is the two-dimensional **plan view**, showing the spatial arrangement or configuration of elements on the ground surface. The plan view can be presented as a composite of different elements or as a series of **element separations**. In the separations, only elements from a given level are shown, each element drawn in outline.

The element separations reinforce the idea that the compositional hierarchy represents a cross section through the generic structure of urban tissue. Each rectangle in the diagram represents all elements of a given type, represented in outline. Drawing a horizontal line through a level in the multi-level diagram 'cuts through' elements that appear in outline in the corresponding element separation. Thus, a line through the level of the plot cuts through plots and street spaces, both of which appear in outline in the plot level element separation.



a) b) c) d)

Figure 5 - Element separations with multi-level diagrams: a) simple tissue; b) plots; c) buildings; d) rooms (the Nolli Section)

In effect, the vertical and horizontal dimensions of the diagram of generic structure represent abstract 'dimensions' of configuration. In simplified terms, the vertical represents complexity and the relationship of part to whole. The horizontal represents adjacency and the relationship of part to part, which implies an abstract notion of extent. When the horizontal section is drawn at the level of the room, it cuts through all three voids in what can be termed the Nolli Section (after the 18th century surveyor who drew his famous map of Rome showing the interiors of notable public buildings, Figure 5d) . This has traditionally been the primary realm of configurational analysis – the investigation of spaces and the spatial relations between them.

One part of the foundation for the bridge between configurational and urban tissue analysis lies in the three analytical diagrams – structured space, element separation and generic structure. By using the structured space diagram to represent elements at all levels in the compositional hierarchy, it is possible to extend the methods of graph analysis as developed by Steadman, Hillier, Hanson and others to all generic types of built form. In this respect the diagram of generic structure helps to situate different methods of analysis and investigation and show their relationship to each other. Steadman's Architectural Morphology (1983) focuses on the room and building as does Hillier and Hanson's Social Logic of Space (1984). Space Syntax focuses on the route, effectively in isolation. Interestingly, the open area or plot has been the subject of very little investigation from the configurational point of view.

The perspective offered by the diagram of generic structure highlights the fact that the spatial configurations of rooms, plots and streets are constituent attributes of urban tissue. They are embedded within the vertical structure of built form. The benefit of this view is that it goes beyond the fairly obvious point that 'spaces are a part of the built environment' (setting aside the deceptively difficult task of formally defining a 'void' or absence) and identifies the specific relationships by which the voids are more easily defined.

The substance of the bridge between configurational and urban tissue analysis is the built environment itself. Our ability to cross it comes from seeing that configuration and urban tissue refer to two different 'dimensions' of the same thing.

Another part of the foundation for the bridge is the complementary relationship between configurational **types** and configurational **measures**. This distinction is rooted in the difference between quantity on the one hand and number and pattern on the other. Quantity is continuous and dimensional where number and pattern are discrete and relational. Something is 'central' only in relation to something that is peripheral but there are degrees of centrality. As emphasised by Steadman (1983), the basis for identifying configurational types is the topological characteristics of the forms – topologically distinct, discrete relationships between elements. The measures, such as depth, integration, choice etc. are used to quantitatively characterise different specific configurations. In its fullest sense, configurational analysis should seek both to identify different configurational types of pattern and compare them (or positions within them) using the quantitative measures.

3. THE BRIDGE OF ROUTE STRUCTURE

The pattern that provides what is probably the strongest and most familiar connection between configurational and urban tissue analysis is route structure.

Routes can be seen in at least three ways:

- as a movement network (infrastructure)
- as an element of urban tissue
- as a defined area of 'land use' and control

The distinction between routes as part of a network or part of urban tissue is a matter of how we choose to aggregate street spaces as one of the three types of minimum elements of urban form. There is, on the one hand the 'vertical' aggregation of elements as represented by a vertical section through the multi-level diagram of generic structure (Figure 6b). This 'embeds' the street space into urban tissue. On the other hand, there is the 'horizontal' aggregation of spaces implied by the Nolli Section through all the three types of void (Figure 6c). The latter view is essentially to isolate the spaces, which necessarily interconnect to allow movement through the built environment. As Figure 6c shows, a network of routes can be rendered using the three access types of structured space (single, double and multiple openings, where a link is a single or double opening space and a node is a space of three or more openings.

a) b) c)

Figure 6 - a) A street space; b) the street space embedded in a simple tissue and c) an aggregate of street spaces forming a network

The approach set out below builds on the work of Steadman (1983) and Marshall (2004) by providing a basic differentiation of routes, as types, based on their position relative to other routes within the network. It is topological and discrete and works on the basic morphological principle of relative position of parts. It is possible, and desirable, to undertake the task of definition – and analysis – from both the bottom up, using the primitives of base structured spaces and the top down using the pattern of routes and settlements.

A fundamental concept for understanding the structure of longer distance route patterns is the **centre**. There are many reasons for the general pattern of nucleated and poly-centric settlements but one way or the other there is a strong tendency for the emergence of centres, that is, concentrations of activity that serve or draw on a wider **catchment**. The formation of centres pre-supposes routes to get to them and, in turn, centres can generate new routes to widen or extend access to them and increase the size of the catchment. The cumulative result is the familiar pattern in the landscape of settlements linked by roads.

To begin to articulate the pattern, it is possible to distinguish different types of route purely with reference to the position of a route in relation to centres and to other routes in the network. The first step in the analysis is therefore to identify the centres.

For the purposes of this stage of analysis, the minimum definition of a centre is any concentration of occupied buildings (departure or destination points) irrespective of use. Typically this corresponds to built up areas as identified on most maps. On this basis, a 'centre' might be a hamlet, village, market town city or metropolitan region. The principal variable to consider is the size threshold for what constitutes a 'concentration'. Depending on the scope of the study the method for establishing the threshold might be a rank-size rule or density profiling. More simply and directly the built up areas as identified on maps can be used, with smaller scale, lower resolution maps generally using a higher threshold of size for identifying settlements than larger scale, more detailed maps. In the UK, the open source Meridian 2 map set is very useful for the purpose.

Primary route types by position

However the centres are defined the first step is to **treat them as a simple structured space**, that is, in terms of the surface, boundary and access points. The next step in the process of analysis is to identify and colour code different route types based on their relation to centres.

The process of analysis necessarily disregards any existing ranking of centres or routes on the basis of designation, size, capacity etc. The aim is to identify route types **solely on their relationships to centres or to other routes**. The analysis is therefore strictly **topological**.

In essence, the first stage of the analysis is carried out at a low level of resolution, distinguishing only built up areas and the routes that are connected to but lie outside them. From this perspective there are four types of **strategic route**:

Tangential: Routes connecting several centres tangentially. The connection to the built up area is only indirect and the priority is for through traffic along the tangential route. Examples are limited access dual-carriageways, motorways and freeways/expressways.

Primary arterial: Routes connected to a centre on each end (bicentric).

Secondary arterial: Routes connected to a centre on one end and a through route on the other (monocentric).

Pericentric: Routes connected on each end to one or another of the higher level strategic route (tangential, primary or secondary).

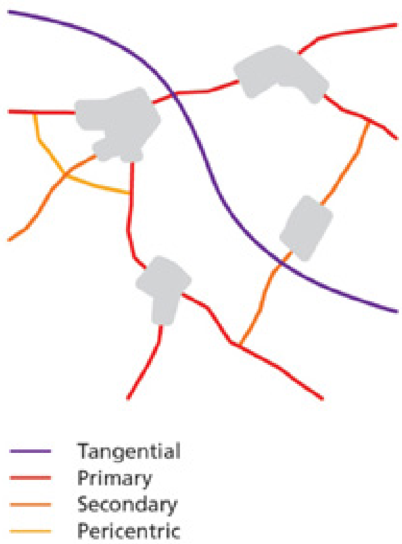


Figure 7 - Strategic route types

Once the external strategic routes have been identified, the next step is to trace the arterials into the built up areas, extending them along continuous routes (assuming forward inertia, right of way and the least angle rule) until they either end in a T-junction or emerge out another side of the built up area. Internal pericentric routes can be added after the internal arterials are identified.

Local route types by position

Working from the bottom up with the base structured spaces, the matrix of access types establishes a topological basis for identifying basic route types at the local level – that is, individual street spaces. There are four basic types of local route in terms of topological connections.

Thoroughfare: Routes connected to a different route on each end.

Through-loop: Routes connected on both ends to the same route.

End-loop: Routes connected to a route on one end and itself on the other.

Cul-de-sac: Routes connected to another on one end only.

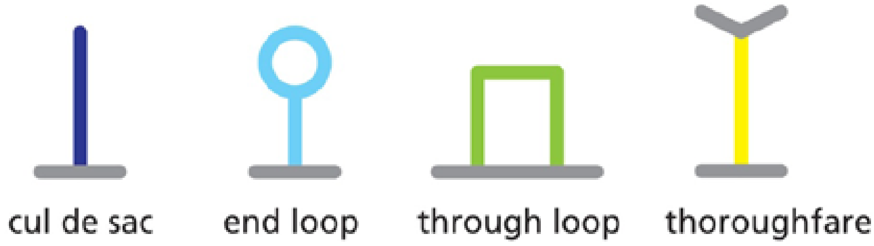


Figure 8 - Local route types

Route structure sub-systems

Examining even a small number of places shows that these types are combined in many different ways. It is possible and not uncommon, for example, to find a loop on top of a loop and many cul-de-sacs along a cul-de-sac. It is also possible to have a grid of thoroughfares at the end of a cul-de-sac. These are sub-systems that form a distinct level of structure between the local and the global. Crucially, **sub-systems** can be outlined and rendered as a single structured space with one, two, three or more openings. There are four types of sub-system, corresponding to the four types of local route.

Thoroughfare: A set of interconnected local routes with three or more external connections to at least two different strategic routes.

Through-loop: A set of interconnected local routes with only two external connections, each to different routes, or multiple connections to a single strategic route or thoroughfare.

End-loop: A set of interconnected local routes with a single external connection.

Cul-de-sac tree: A composition of only cul-de-sacs with one external connection.

Figure 9 - Strategic routes and route sub-systems for vehicle access in central Bath. The colour coding for the sub-systems is the same as for the local types (Kropf 2014b)

The most effective and familiar method of representing the types is to colour code them using the heat map convention. In most cases it is best to code the strategic routes and whole sub-systems. Colour coding whole sub-systems necessarily ignores the type of some of the component links. The result, however, gives a clearer general picture which can be augmented if appropriate with a separate more detailed coding of individual local links.

What is of particular relevance for this paper is that route structure sub-systems also define an area that can be outlined as a structured space. Drawing a boundary around a sub-system based on its configurational type is, in effect, a first step in identifying an urban tissue. That is, if urban tissue is defined as an area of a settlement with a distinct and consistent configuration of streets, plots and buildings, the configurational type of the street pattern is one of the attributes used to identify the tissue. The constituent role of the street pattern in urban tissue is highlighted in the diagram of generic structure (see Figures 4 and 5). The street space is the 'operational void' of urban tissue that works with plot series and blocks, which themselves contain the other voids at different levels.

The two views - the part-to-whole aggregate/'vertical section' through generic structure of urban tissue and the part-to-part aggregate/'horizontal section' of route structure - are, in effect, two different views of the same thing. There is, then, a 'structural overlap' or common element used in both configurational and urban tissue analysis. The configurational approach treats route structures as aggregates of spaces and identifies configurational types of aggregate. The typo-morphological approach uses types of route structure as one element of several in identifying types of urban tissue.

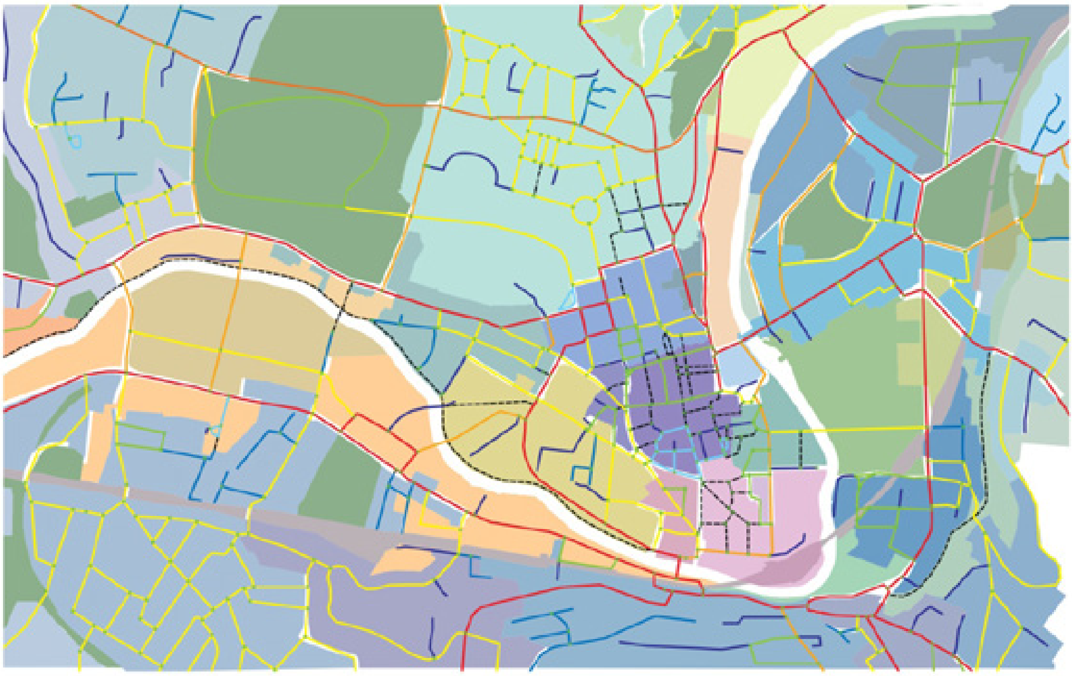


Figure 10 - Route structure types and tissue types in central Bath (Kropf 2014b)

4. CONCLUSIONS

The two approaches and their respective views are not mutually exclusive but intersecting. Most importantly, the 'structural overlap' makes it possible to accurately combine the results of different methods The same element is analysed or measured in different ways. There is an added benefit or 'yield' when the results are compared, similar to the depth perception gained with binocular vision. As shown by Bateson (1980) and Jones and Lee (1981) there is an informational and performance 'bonus' when two views of the same thing are compared in the brain. Bateson cites other examples of the same principle, which he terms 'multiple description', the essence of which is comparison. Another visual example is toggling between two images of the same view at different times. When toggled quickly enough, any change appears to the brain as motion. What is highlighted in the comparison is a relationship – 'this is in front of that' or 'there has been a change in position/time.'

Viewing types of urban tissue and configurational route types together brings out the structural depth of the area being examined in terms of: the relationships of the internal parts to the whole; the relationships between different tissues; the nature of their connections; the relationships between a given tissue and the settlement as a whole.

A further benefit of the structural overlap lies in the fact that the area of overlap – route structure – is the principal subject of the analytical methods of Space Syntax and network analysis. An additional yield can therefore be gained by combining and comparing route types with measures such as integration, choice and connectivity. Adding measures with a clear, structural point of reference adds more depth to the view and provides a foundation for making more finely tuned inferences and judgements by clearly articulating the context for the measures. When looking at the spatial distribution of such things as crime, property values or perceptual qualities it becomes possible to look at correlations with type, measures and relative position. The combination of type and measure is more powerful than either on its own.

In summary, there would seem to be at least three core benefits of combining the configurational and typo-morphological methods. 1) The configurational view adds a rigorous, topological foundation to the identification of urban tissue. 2) The sub-system types and tissues establish a more specific context for configurational measures. 3) The combination allows more nuanced and pointed comparisons and correlations and a wider range of inferences to be made. Combining methods with a common structural reference provides a yield of additional information and insight that helps to improve our understanding of urban form.

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