When Is a Door More Than a Door?

The role of constitution in strongly geometric configurations

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Abstract

This paper is about the role of layout and "constitution' in the urban environment. By constitution, it is meant the pattern and distribution of building entrances within a network of spaces. It would seem self-evident that layout and constitution are mutually-dependent aspects of urban function; in that to access one on any journey, it is necessary to access the other. However, it can be argued that in strongly geometric configurations, constitution can take on a more substantive role. In particular, that the pattern and distribution of dwelling entrances can embed the emergent "structure' - as defined by Hillier - of a growing urban layout with a degree of coherence otherwise lacking when using standard representations of the space syntax "canon' (Hillier, 1996). Constitution can play this role by "stabilizing' the emergent patterns of global and local integration. By stabilize, it is meant render with a degree of consistency over time. Why constitution can take on this role arises because of the tendency for the integration pattern in strongly geometric configurations to "shift' with reference to overall shape of the settlement during the process of growth (Major, 1997 and 1999). The effect of constitution on emergent structure is demonstrated by conducting space syntax analysis of the historical growth of Savannah, Georgia (1733-1856). Savannah is an unique and almost ideal model of urban growth, occurring over a sustained period of time in a strongly geometric and highly controlled manner. The paper then builds on Anderson's earlier arguments about the Savannah plan as a "resource' for interpreting the social and functional structure of the historical settlement (Anderson, 1982 and 1986). It is argued that the findings of the paper could have widespread implications since the location, size and density of built forms - when taken together - can be seen as the essential construct of "origins' and "destinations' in prevailing planning theory. Finally, with the continuing advancement of computational power, it is concluded that constitution can now be seen as the fundamental medium by which we can progress from a purely configurational to more comprehensive approach - incorporating spatial pattern, constitution, floor area and building height - in modelling all types of cities; whether strongly or weakly geometric in layout. It is suggested that a more comprehensive approach could allow us to more significantly contribute to the evolution of design principles, in movements such as The New Urbanism, for the future benefit of all our cities.

Keywords:
Configuration, Constitution, Geometry, New Urbanism, Savannah

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Geometry and Emergent Structure

The emergent structure of strongly geometric configurations will tend to be characterized by "shifting' during the process of growth (Major, 1997 and 1999). By "shifting", it is meant a significant change in terms of where the most integrating spaces of the configuration are located over time. In particular, the integration core will tend to shift from location to location over time unless the layout is grown in a perfectly geometrical manner (Major, 1997). By this we mean, new layouts aggregated during the process of growth are congruent with the

intrinsic geometric logic of street connections, block sizes, and overall shape of the settlement as originally founded. If this does not occur, then shifting will often be primarily determined by the emergent shape of the overall settlement rather than the intrinsic logic of street connections (Major, 1997), indicating a prevalence of geometry over configuration in, at least, the earliest stages of growth. This can be demonstrated using theoretical models. Figure 1a shows a perfect 5 x 5 geometrical layout (4 x 4 block pattern). It is perfect in the sense that all blocks are the same size and shape and all streets of the same width and length, connecting to exactly one-half of the total number of streets. Figure 1b shows that the pattern of metric integration in this layout is symmetrical from center-to-edge and center of edge-to-corner, as previously identified by Hillier (Hillier, 1999).[1] This pattern can be seen as broadly consistent with the pattern of integration previously identified by Hillier in perfect geometrical layouts using all-line axial analysis (Hillier, 1996). What this indicates is though a settlement may be founded using a perfect geometrical layout, such settlements are already possess a spatial structure during the earliest stages of their existence, which we can conclude would have some effect on patterns of urban function within them.[2]

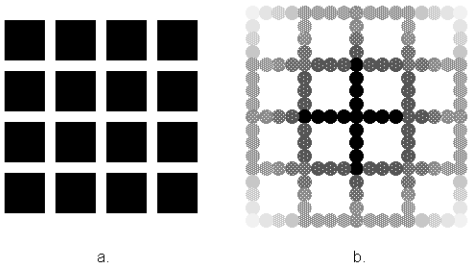

Figure 1. (a) perfect 5 x 5 geometric grid pattern (4 x 4 block pattern) and (b) the center-to-edge, edge of center-to-corner pattern of metric integration.

Once this settlement begins to grow, and this layout is expanded, the effect on alternating this spatial structure, and presumedly the pattern of urban functions already established within it, can be dramatic if growth is not handled in a manner sensitive to this structure. This is demonstrated in Figure 2. Figure 2a shows the settlement expanded into a 9 x 13 grid pattern (8 x 12 block pattern). The area of the original 5 x 5 layout is in black, the extension of preexisting routes in dark grey, and new routes introduced to the settlement in light grey; using the least-line representation of the space syntax "canon' (Hillier and Hanson, 1984). The axial analysis of this enlarged settlement is shown in Figure 2b. It indicates that all north-south routes are highly, and equally, integrated (5.63), and all east-west routes are similarly segregated (3.75). More significantly, however, there is no differentiation in terms of integration value between those spaces which are extensions of preexisting routes and those which are later additions. We can conclude the geometric logic of the enlarged settlement is consistent with its original layout but that the emergent structure of the enlarged settlement - defined in terms of its new integration pattern - is inconsistent since it has dramatically shifted without any obvious reference to the spatial structure identified in Figure 1.

Review of the historical record (Moholy-Nagy, 1968; Clay, 1972; Reps, 1965 and 1979; Kostof, 1991 and 1992), however, provides suggestive evidence that this is almost always compensated for in some manner during the process of growth by the manipulation of block sizes and shapes (upscaling and block subdivision), street lengths (interruptions and deformations), or both (Major, 1999). The effect of this is to "marginalize' shifting by privileging some spaces, and areas, over others within the emergent structure of the settlement. By marginalize, it is meant that the most integrated spaces will tend to remain in the highest ranges of integration in the emergent structure of the growing settlement. Some examples of how this is achieved are shown in Figures 2c-f. In Figure 2c, the settlement is grown in a manner similar to that shown in Figures 2a-b but incorporating block subdivision within the

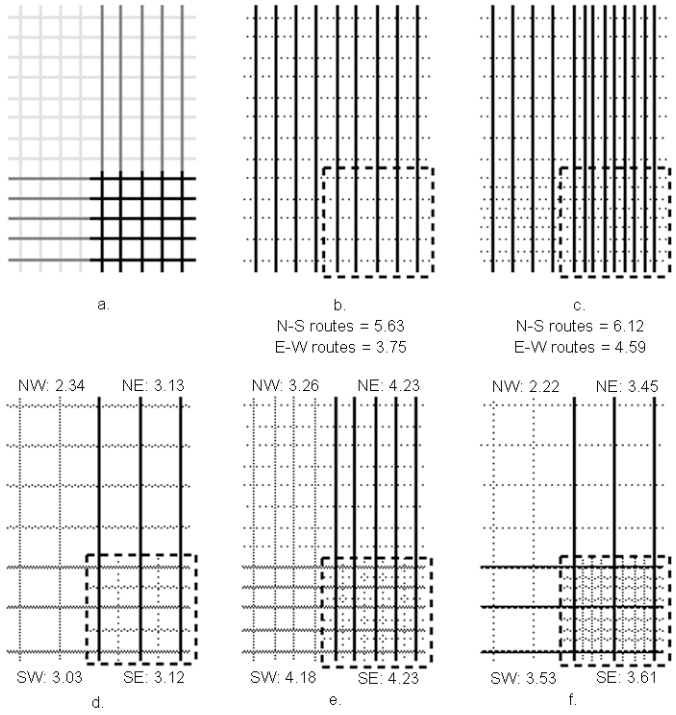

Figure 2. (a) original 5 x 5 grid pattern shown in black, extension of preexisting routes shown in dark grey and the new routes introduced are shown in light grey; (b) integration pattern of new, expanded grid pattern with the area of the original 5 x 5 layout outlined in black; (c) integration pattern incorporating block subdivision in the original 5 x 5 layout; (d) integration pattern incorporating larger block sizes in periphery growth; (e) integration pattern incorporating block subdivision in, with some routes remaining internal to, the original 5 x 5 layout; (f) integration pattern incorporating larger block sizes in periphery growth and block subdivision in, with some routes remaining internal to, the original 5 x 5 layout.

area of the original 5 x 5 layout. The result of spatial analysis is similar to that in Figure 2b, with the only difference being there are more routes passing through, and connecting in, the original area of the settlement. However, measured purely in terms of integration value, there is still no differentiation between the original layout of the settlement and its new areas, or between extended routes and those new ones introduced to the settlement since all streets still connect to exactly one-half of the total number. As in Figure 2b, all north-south routes are highly, and equally, integrated (6.12) and all east-west routes are similarly segregated (4.59).

In Figure 2d, this can be modified by terminating alternating routes in the original 5 x 5 layout while extending other routes in a manner similar to that in Figures 2a-c. This is done by introducing larger blocks in the periphery of the enlarged settlement. The effect is to differentiate areas of the settlement into quadrants, including the original 5 x 5 layout, for their degree of integration. The mean integration of all routes within the southeast quadrant (original layout) and new northeast quadrant is equal (3.12 and 3.13, respectively), the southwest is 3.03, and the northwest is 2.34. Even though we have successfully introduced differentiation in terms of integration pattern, aggregating to the layout in this manner has not significantly privileged the original layout within the emergent structure of the settlement in numerical terms. In Figure 2e, this differentiation of quadrants is taken further by enlarging the settlement again in a manner similar to Figure 2a-b but incorporating block subdivision in the original 5 x 5 layout. This generates smaller blocks and a series of alternating routes which are interrupted at the edges of the original layout, i.e. remain internal to the boundaries of the settlement as founded. The effect is similar to that seen in Figure 2d. The mean integration of all routes within the southeast quadrant (original layout) and new northeast quadrant is again equal (4.23) and the southwest moderately integrated (3.53), with the northwest again the most segregated (3.26). Finally, the strongest degree of differentiation in terms of integration can be seen in Figure 2f, where larger blocks are introduced in the

periphery of the enlarged settlement (as in Figure 2d) and block subdivision occurs in the original 5 x 5 layout (as in Figure 2e). The effect is to more strongly differentiate areas and clearly privilege the original layout within the whole. The mean integration of all routes within the southeast quadrant (original layout) is 3.61, the southwest (3.53) is now marginally more integrated than the northeast (3.45), whereas the northwest remains the most segregated (2.22).

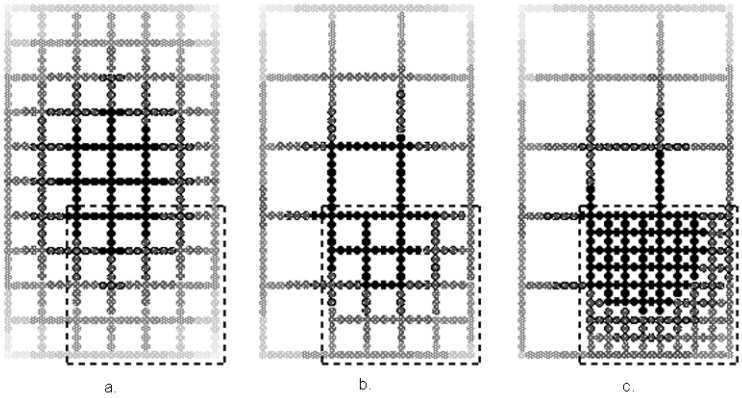

Figure 3. Pattern of metric integration in the area of original 5 x 5 layout in the enlarged settlement based on: (a) same geometric logic and block sizes in new areas to the north and west; (b) larger block sizes in new areas to the north and west, and; (c) larger blocks sizes in new areas to the north and west, and block subdivision with the interruption of some routes in the original area of the grid.

In Figure 3, the effects of enlarging a geometric layout in the manner shown in Figures 2b, d and e on the resulting pattern of metric integration is analyzed. In all cases, the area of the original 5 x 5 layout is outlined in black. Figure 3a indicates that expanding the geometric logic of the original 5 x 5 layout to the north and west shows a similar shift in the pattern of metric integration to the new geometric heart of the settlement, located at the extreme northwest corner of the original layout. Figure 3b shows that using larger blocks in the new areas of the settlement results in a less dramatic - though still clearly discernible - shift to the northwest in the pattern of metric integration, with the highest levels of integration located in the northwest "quadrant' of the original layout. Figure 3c shows that using larger blocks in the new areas of the settlement, and block subdivision in the area of the original layout, results in a marginal shift to the northwest; and that the most highly integrated areas of the original layout more or less maintain their degree of integration within the enlarged whole.

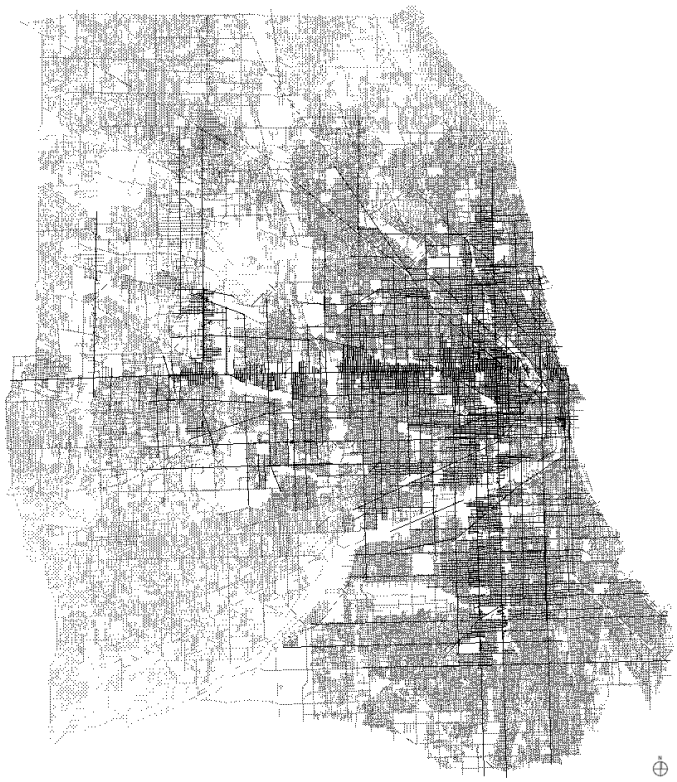

Figure 4. Pattern of (x2)global integration in the axial map of present day metropolitan Chicago, Illinois.

If we now examine a couple of real cases - Chicago, Illinois and New Haven, Connecticut - which were historically

founded as strongly geometric layouts, we can begin to confirm the effects of manipulating block sizes and shape, and street lengths, during the process of growth. Figure 4 shows the pattern of (x2)global integration in the axial map of present day metropolitan Chicago. The historical area of Chicago (present central business district known as "The Loop") is outlined in black. This area outlined is equivalent to one square kilometer. We can see that very large areas of the metropolitan Chicago grid are defined by a strong geometric logic. This geometric logic is principally based on rectangular blocks and street connections of 90˚, resulting in a series of highly integrated, cardinal direction routes crisscrossing the urban grid. We can also see this strong geometric logic breaks down in the more peripheral, 20th century suburban areas of the Chicago, which are characterized by deformed grid layouts. Finally, it is clear that the principal integration core of Chicago has shifted to the northwest of the historical center of the city over time. Figure 5 shows a historical map of the Chicago plan in 1834, which clearly demonstrates the rules of rectangular blocks and street connections of 90˚ governing the early layout of the town. It is also apparent that different areas of the layout are characterized by a different block structure: the area to the east located along the coastline of Lake Michigan has small blocks; the area to the southwest, located at the junction where the Chicago River splits into branches, has slightly larger blocks; and, the area to the south has larger blocks. This would seem to suggest that the early growth of the Chicago plan was largely defined by a process of upscaling block sizes with expansion of the grid, whilst utilizing smaller blocks in the earliest areas of the urban grid, either as originally planned or arising from systematic process of block subdivision. It seems apparent from the historical record that these large urban block structures in the growing periphery of American towns would later undergo a similar process of block subdivision with subsequent growth.

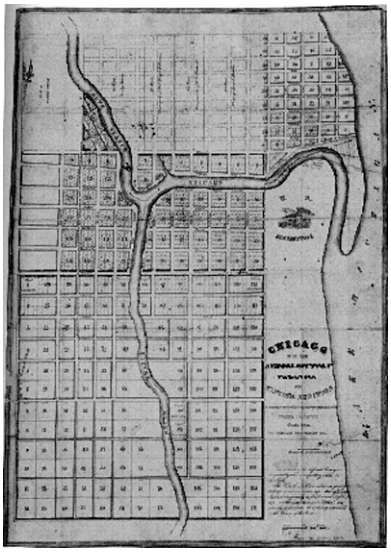

Figure 5. Chicago, 1834 (from Reps, 1965; 301).

The patterning of block structure with growth, and its long-term effects on the configurational pattern of the street network, can be discerned in spatial analysis of present day Chicago. Figure 6 shows the "one-deep system' in the axial map of metropolitan Chicago. The one-deep system is the two most integrated lines forming a cross-axis and all spaces which directly connect to them (Major, 1997 and 1999; Hillier, 1999). What it indicates (with reference to Figure 4) is: first, that the integration core of Chicago has clearly shifted to the northwest over time; and second, block structure and extension of existing gridlines in historical area of the urban grid has been patterned over time so as to more or less maintain its degree of integration within the enlarged metropolitan region. This can be discerned by the series of highly integrated north-south and east-west routes with their epicenter of connection in "The Loop". If we examine the historical growth of New Haven, Connecticut, we can see a slightly different realization of the same principles based on a process of grid deformation rather than expansion. Figure 7 shows the historical growth of New Haven, Connecticut (1638-1852) with urban blocks shown in white, spaces in black, and the blocks in the area of the settlement as original founded shaded in grey. We can see that there are a few, specific spaces passing through the original layout of the town which have been extended outward to the new periphery of the enlarged settlement over time. More importantly, there is a well-defined process of block subdivision in the area of the original layout over time, the cumulative effect

of which is privilege the historical center as the settlement has grown (see Major, 1999 for a more detailed discussion). The manner in which this occurs over time is different from Chicago, especially in terms of geometry, but the results are similar. It is also suggestive that the manipulation of block sizes over time in Chicago and New Haven appears to be consistent with Hillier's earlier arguments about the effect of larger and smaller urban blocks on integration pattern (Hillier, 1999).

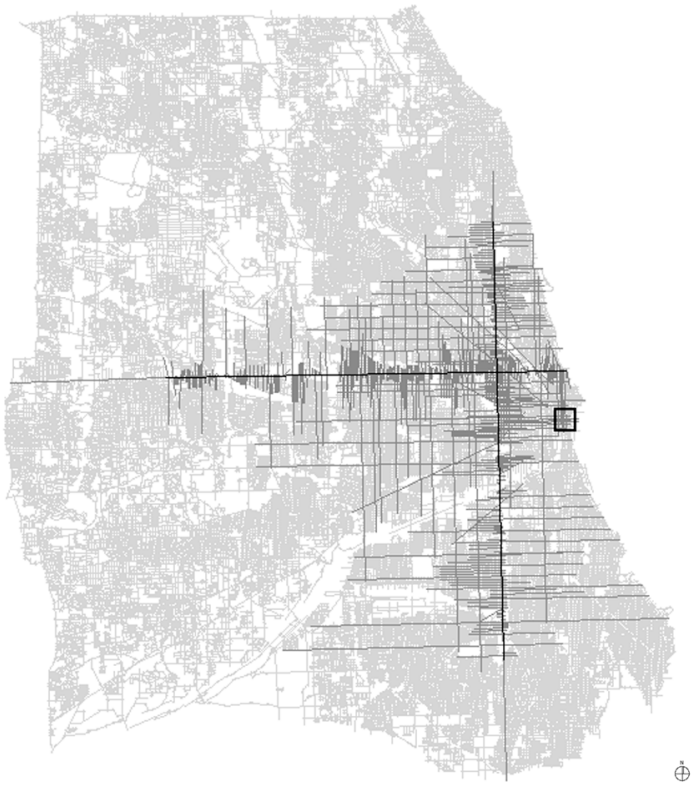

Figure 6. One-deep system from the two most integrated lines in the axial map of metropolitan Chicago. This shows how a set of spaces passing through 'The Loop' (historical area of Chicago and current CBD) have remained privileged with reference to the cityYs integration core.

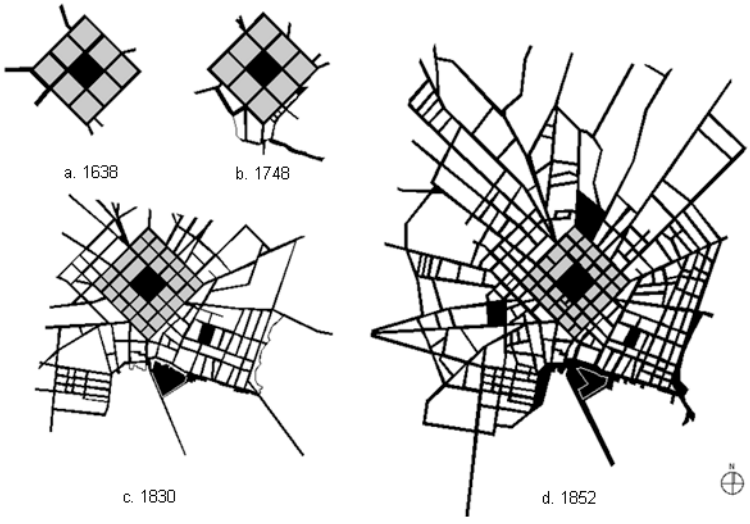

Figure 7. Historical growth in New Haven, Connecticut, 1638-1852 with blocks shown in white and spaces in black. The area of the original settlement is shaded in grey.

The Case of Savannah, Georgia

Taken together, this analysis and review of the historical record would seem to provide suggestive evidence that block sizes and street lengths are almost universally manipulated during the process of growth in strongly geometric configurations (Clay, 1973). The effect would seem to be to render this tendency for integration patterns to shift in the emergent structure of the growing settlement either marginal or compensated for in some fashion, usually quite early in the growth process. However, there is a historically important settlement where this is clearly not the case; at least during the first 123 years of its existence. Savannah, Georgia grew in a strongly geometric and highly controlled manner unparalleled, from its founding in the early 18th century until just a few years before the American Civil War. This pattern of growth is shown in Figure 8. We can see that the manipulation of block sizes and street lengths commonly found in other American settlements was, for the most part, absent in the Savannah plan during this period (Reps, 1965; Anderson, 1982). Because of this, Savannah represents something of a paradox in urban history, in terms of: how the settlement functioned within its strongly geometric constraints, given the problems of coherence between geometrical layouts and configurational patterns already discussed; and, in its perception by so many (Reps, 1965; Kostof, 1991) as an example of classical urban design principles on one hand be reconciled with the reality of its manifest lack of influence as a model urban form in the American history.

By attempting to resolve this paradox, the paper sets out to answer two questions: first, by conducting spatial analysis - with reference to historical and theoretical descriptions of the settlement - can we better extrapolate how historical Savannah might have functioned as a social and economic entity; given that it would have been subject to these spatial effects of

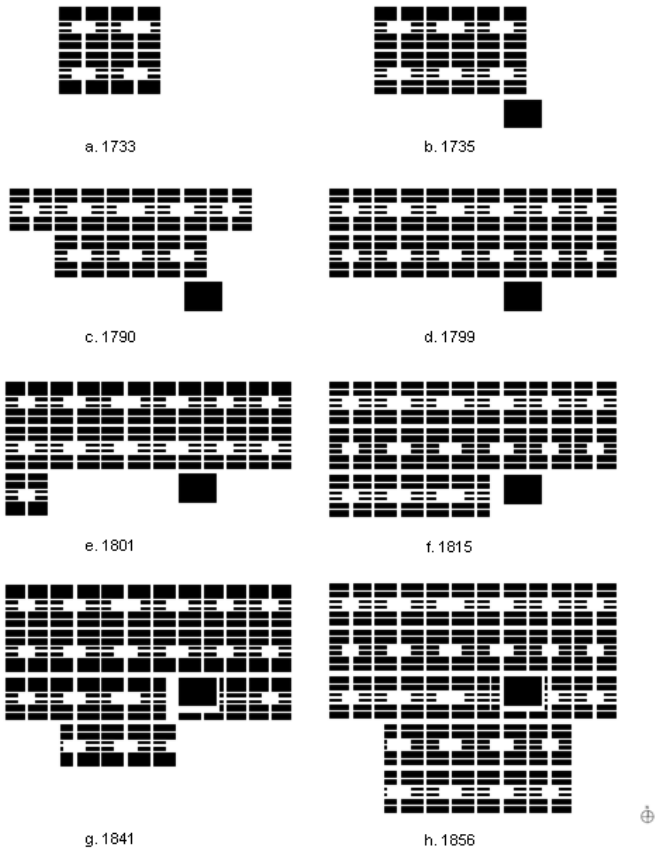

Figure 8. The Growth of Savannah, Georgia, from 1733 to 1856 (after Reps, 1965; 201).

geometric growth; and second, can the spatial analysis of an apparently unique type of urban model provide any useful knowledge which can be seen as generic to other types of settlements?

If we begin by first analyzing the settlement in purely configurational terms, based on the layouts shown in Figure 8 and using the least-line representation of the standard space syntax toolkit (Hillier and Hanson, 1985), we can see that the configurational pattern of the settlement is characterized, as we might expect, by an "instability' in its global and local integration pattern (Figure 9). This shifting pattern of global and local integration results from additional wards being aggregated to the settlement and it seems clear that this instability derives from the evolution of overall settlement shape, dependent upon where these wards are added. However, if we contrast this configurational analysis to historical descriptions of the settlement, it would seem that there was some consistency in the pattern of urban function (i.e. the location of the commercial and retail center) over time (Anderson, 1982; Reps, 1968 and 1979). At first glance, this would seem to indicate that spatial analysis does not provide an adequate description of the spatio-functional nature of the historical settlement.

However, with reference to Anderson's earlier arguments about the differentiation of east-west and north-south street frontages in the historical settlement (Anderson, 1982 and 1986), we can develop a spatial model which does seem to provide an adequate description of its spatio-functional nature. This can be done by weighing the axial model of the settlement for the location of dwelling entrances and the relative floor area plate to which these entrances

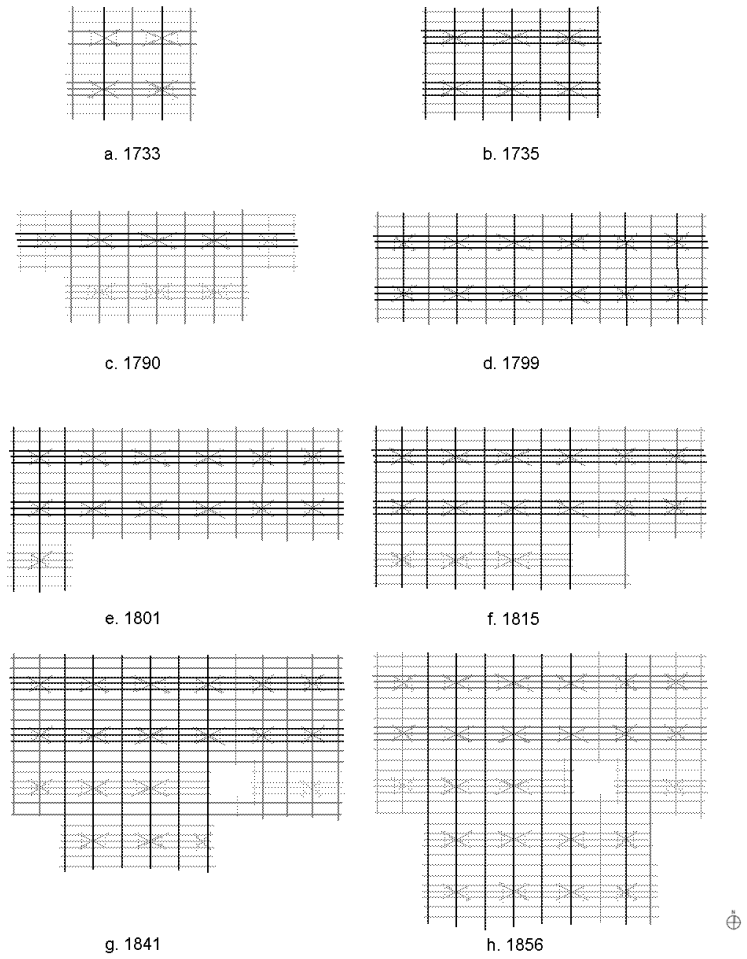

Figure 9a. Pattern of (x^2)global integration in the growth of Savannah, Georgia, from 1733 to 1856.

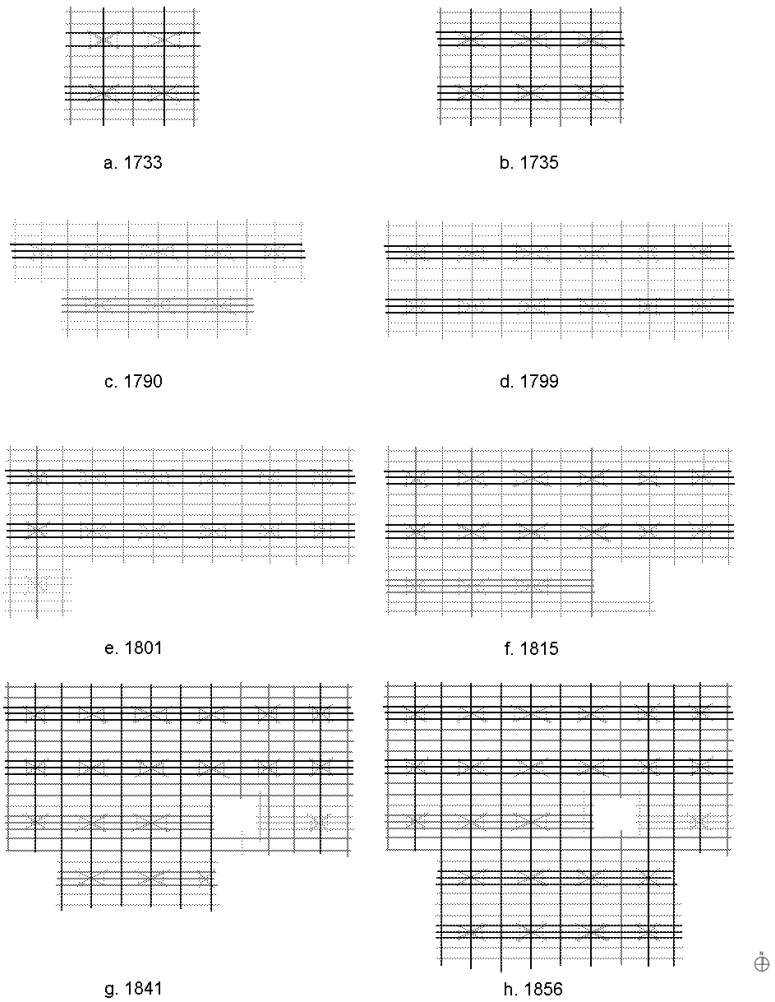

Figure 9b. Pattern of (x^2)local integration in the growth of Savannah, Georgia, from 1733 to 1856.

provide access. We can see the pattern of dwelling entrance locations and relative floor plate area in the 1856 historical plan of Savannah, which is quite detailed in this regard. This type of weighing of axial models builds upon earlier experimental, and unpublished, modelling conducted in the space syntax research program at UCL within the context of consultancy work as well as more rigorous investigations linking spatial configuration, built form density and land uses using PESH modelling and GIS systems (Hillier et al, 1995). Though the resulting representation is admittedly a form of "shorthand' in terms of modelling technique - designed to point towards answers to the questions we are investigating in this paper rather than the development of rigorous representational technique - it does reflect an ongoing evolution towards more integrated representations of the built environment in space syntax research. The evolution of representational technique will, hopefully, become more intuitive to the naked eye with the continual advancement of computing technology, processing speeds and software development.

Once we do this, we can see that the effect of weighing for constitution and floor area on integration pattern of the settlement is to stabilize that integration pattern in Savannah, making the pattern consistent over time (see Figure 11), with the dramatic shifting in global and local integration patterns seen in the purely configurational representations of the historical plans of Savannah now virtually eliminated. It is argued that this weighed axial model

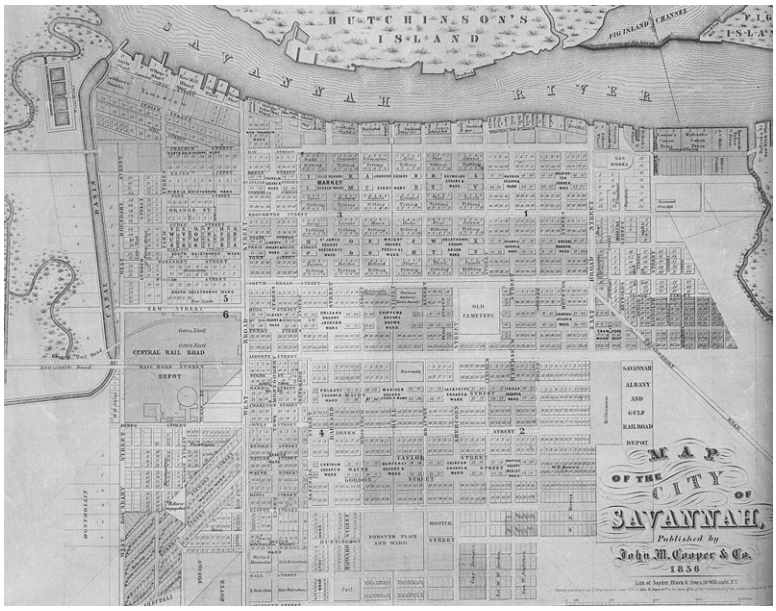

Figure 10. Pattern of plot divisions in the 1856 plan of Savannah, Georgia (from Reps, 1965; 200).

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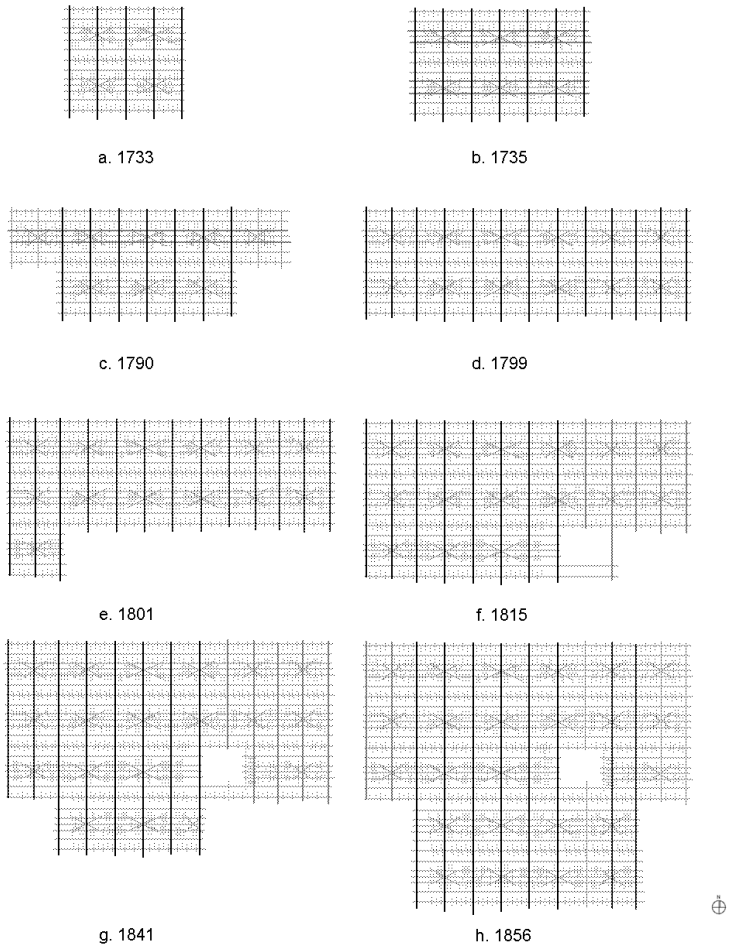

Figure 11a. Pattern of (x^2)global integration in the growth of Savannah, Georgia, from 1733 to 1856, weighing for constitution.

does seem to provide a more adequate description of the spatio-functional nature of the settlement as described in the historical record and that we can see that this nature is intimately bound up in the geometry of the layout, the location of dwelling entrances and the density of built forms (as simulated in terms of floor plate area).

More than this, however, the analysis would seem to confirm in principle Anderson's hypothesis that in the spatial structure of historical Savannah,

> "movement along east-west streets serves for continuous opportunities of access to similar uses; movement along north-south streets provides comparatively rapid access to zones of alternative uses' (Anderson, 1986; 275)

and, in this manner,

> "the resident of Savannah could read the social structure of his city in the location of fashionable houses lining the squares, separated from the most modest dwellings on side streets' (Rybczynski, 1995; 77).

However, by relying on historical descriptions of the town we can take Anderson's hypothesis slightly further and conjecture on the very nature of these "alternative uses', which Anderson argues north-south routes facilitate access to, in how the town relates to the outside world (Anderson, 1982). The historical record indicates that the key activity space of the town was the northernmost route where the city's port was located:

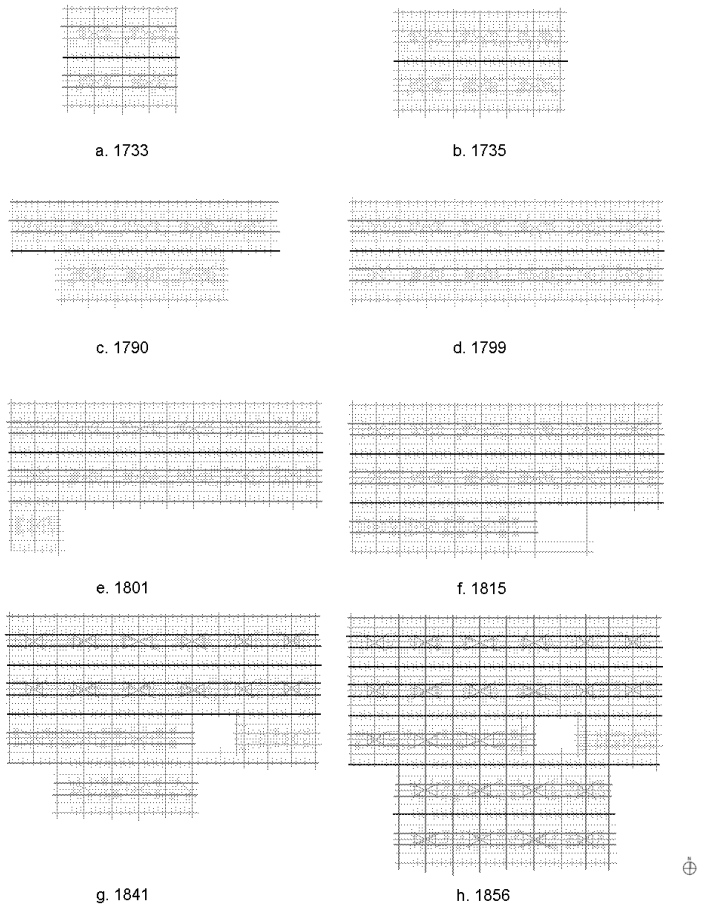

Figure 11a. Pattern of (x^2)global integration in the growth of Savannah, Georgia, from 1733 to 1856, weighing for constitution.

> "...this street, which is called 'The Bay" is the principal resort for business. The counting-houses, warehouses and best shops, are along this bay; the Exchange and Post Office as well as the city office are here"(Reps, 1965; 202).

It is in the 'intricate interaction of abstract geometry and use patterns, each modifying the other' (Anderson, 1986; 275), that we can now see that the town is defined by a highly structured hierarchical order from 'outside to inside' whereby the main relationship to the outside world is defined by the port, and the north-south streets running from it which provide access to the town. The inhabitants of the town are marginally separated from the 'global' structure by a change in direction with access to the dwellings of residents located along east-west streets. From the port into the town, one moves from the global relationship of "being outside and entering' to the local relationship of 'being inside'. It is in this manner that the stranger-inhabitant interface in the historical settlement is structured. Because of this, the spatial and social hierarchy of the town is quite clear, whereby geometry, spatial pattern, constitution, and the functional patterns of land use and movement, all serve to reinforce this structure. The hierarchy reads quite simply from outside-to-inside as global centrality (port), global linearity (north-south streets), local linearity (east-west streets) and local centrality (i.e. squares). We would suggest that this makes the historical plan of Savannah probably one of the most subtle - yet highly - ordered examples of urban design in the history of town planning.

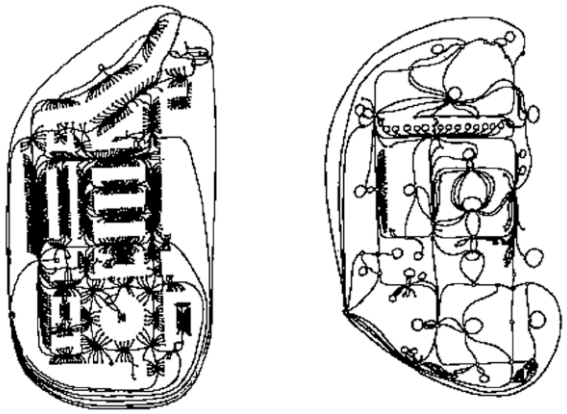

Figure 12. Pattern of constitution in Somerstown, London (UK) (a) before and (b) after reconstruction from terraced housing to modernist social housing (from Hanson, 1999).

In generic terms, we would argue that this suggests the critical role of constitution can play in urban environments, especially strongly geometric ones. Constitution has often appeared as a variable in treatises on urban design and planning, (Jacobs, 1961) as well as research using space syntax; the most obvious example of the former being Jacobs' call for 'eyes on the street' in her discussions of urban safety and, in the later, Hanson's study of Somerstown in central London (see Figure 12) (Hanson, 1999). But the general impression seems to be, especially in space syntax research, that constitution has been at best a background - and unquantified, though obviously graphically well-represented - variable in mainline configurational studies; if it is even examined at all which is more often not the case. We would argued that this should no longer be the case, that enough preliminary findings have emerged, such as the ones presented in this paper and in Hanson's earlier work, which merge the modelling of layout with weighing of constitution that we should now seek to develop representational techniques which prescribe a more integrated view of the urban environment, with spatial configuration as the foundation of this new view. Taking a more integrated approach to researching the urban environment, in the way we represented those environments and not just handle data, could make a more significant contribution to the future design of our cities; especially in the area of public policy, where space syntax has always been weak.

Implications for Professional Practice

Building on the already considerable success of space syntax research around the world to the evolution of more integrated representations of the urban environment appears to be a natural progression of the space syntax lexicon. It is a step which would solidify the already slow merging of data visualization we now see in GIS specializations deriving from ever faster computing technology which allows architects and urban designers to incorporate social variables in an analytical manner in design development, and planners to physically attribute social and economic data which would have previously been examined in isolation from the physical environment. In a very real sense, developing integrated representations which bring variables such as constitution, floor plate area and building height to the forefront of space syntax research by partnering them to the foundation of spatial configuration would represent: 1) a significant merging of concurrent research programs on built form and density at Cambridge's Martin Centre (Martin, 1972) with that of spatial configuration at UCL's The Bartlett (Hillier and Hanson, 1984; Hillier, 1996; Hanson, 1998), as well as their outshoot programs around the world; and a significant bridging of the architecture and planning disciplines founded upon the rapprochement evidenced by architect's increasing development of analytical representations of social, economic and functional data as an input into the design process and planner's increasing attribution of this type of data to physical locations evidenced by the emergence of GIS systems.

We would conclude the paper by arguing that this progression towards the merging of research programs and academic disciplines will have widespread benefits for professional practice, especially movements which have taken on the mantle of sustainable urban development and by definition have postulate views of the urban environment which mix together multiple aspects of that environment. Included among these are The New Urbanism; where constitution forms a fundamental tenets of a design philosophy (Calthorpe, 1993; Duany, 1985) (see Figure 13). In many cases, the new urbanists - in arguing for sustainable urban development based on a dense mix of built form types, land uses and constitution pattern - have too often relied on the precedent of traditional urban forms rather than current, quantitative analysis already available and continually being added to in order to substantiate their claims. A more integrated representation on the urban environment would allow researchers to take on more complex issues with reference to design implementation in the development of public policy while at the same time allowing us as researchers to better contribute to the evolution of design principles in movements such as The New Urbanism. In this way, the relationship between research, practice and policy will be to better enable us to realize the goals of integration rather than detachment, engagement rather than conflict, sustainability rather than malaise, and multi-disciplinary approach rather than disciplinary dogma.

Figure 13. Street frontages in New Urbanism settlements (a) Seaside, Florida (© Seaside Institute) and (b) Celebration, Florida (© Disney Corporation).

Notes

(1) '...metric integration arises from the suggestion that the success of syntactic integration as a measure is that it is ultimately an expression of 'universal distance' (Hillier, 1996, Chapter 3). This is defined, in contrast to 'specific distance' which measures the distance from a to b, as the distance from one point to all others in a shape. In practice, this is shown by representing a shape as an arbitrarily fine tessellation, then treating the tessellation elements as the nodes of a graph

and the facewise joins between elements' edges. Configurational measures can then be applied in the normal way, giving results such as measures of shape, expressing mean trip distance within the shape, and other measures analogous to area:perimeter ratios' (Hillier, 1999).

(2) It is also true that this spatial structure will usually be modified or enhanced by the relationship of the settlement to the outside world, i.e. other settlements in the geographical region or to surrounding agricultural lands (Hillier, 1996; Major, 1999).

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