ARE AMERICAN CITIES DIFFERENT?
if so, how do they differ

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'...because the point about this giant city, which has grown almost simultaneously all over, is that all its parts are equal and equally accessible from all other parts at once.'

Reyner Banham
Los Angeles: The Architecture of Four Ecologies

'...you come upon the horizontal infinite in every direction... you will never have encountered anything that stretches as far as this before. Even the sea cannot match it, since it is not divided up geometrically. The irregular, scattered flickering of European cities does not produce the same parallel lines, the same vanishing points, the same aerial perspectives either. They are mediaeval cities. This one condenses by night the entire future geometry of the networks of human relations, gleaming in their abstraction, luminous in their extension, astral in their reproduction to infinity.'

Jean Baudrillard
America

0 Abstract
The paper presents the findings of a comparative study of the metric and syntactic characteristics in 12 American and European urban grids using space syntax. This is done in order to more objectively quantify how the spatial structure of American and European cities might be similar or different. It is suggested that American urban grids are structured and differentiated rather than purely geometrical objects. However, as urban systems they are models of formal maintenance, in that as they increase in size they tend to maintain their formal composition. This in contrast to European urban grids which can be seen as models of spatial maintenance in that as they increase in size they tend to maintain their prevailing spatial pattern. It is argued that this arises primarily through the initial conditions of geometry and deformity in the urban grid which serves to intensify the initial differences between American and European urban grids. However, as they increase in size these differences in spatial structure become less pronounced. The implications of this in researching American cities are discussed.

1 The Problem of the Geometric Grid
Each of the quotes above about American urban form were written from a different point of view. Banham was an architectural historian interested in identifying the physical components which, aggregated over time, gave rise to the distinctive shape of a city (Banham, 1971). Baudrillard is a sociologist interested in the cultural traits of a people as symbolised by the type of cities they build and inhabit (Baudrillard, 1986). Each author was writing about the city of Los Angeles as a 'model' of American urban form, that is as typical of how American cities are now or are likely to be in the future. This model is clearly identified - large cities composed of long, straight streets

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realised within a rigid grid geometry which 'neutralises' any differences between specific locations within the grid by virtue of the geometry itself, i.e. 'all its parts are equal' (Banham, 1971).

This model has often been contrasted with the European model - small cities composed of short and labyrinthine streets within an 'organic' grid, that is a deformed grid without an obvious geometry (Hillier, 1999). Its lack of obvious geometry is seen as generating a strong differentiation between specific locations within the grid. The idea behind these contrasting models would appear to be that American cities are not structured in the same way as European cities. For example, the word hierarchy has often been invoked for European cities in a way it rarely is for American ones. In a sense, the American grid seems to be thought of as conceptually equivalent to an 'isotropic plane', where each location within the plane is equal to every other location in all directions.

This would seem to fit well with established ideas about an American democracy affording opportunities for all individuals regardless of race, colour or creed. In architectural writing this is often reflected in the well-worn phrase 'the democracy of the grid', what Copjec refers to in her article 'The Grid and the Logic of Democracy' as a conceptual equivalence between democracy and the regular grid (Copjec in Gandesonas, 1981). Again, this is often contrasted with European cities where the description of spatial structure would seem to denote a conceptual equivalence between the organic, deformed grid and a tradition of monarchy and a hierarchic class structure.

If true this would have an important implication for researching American cities. It would mean that the social and economic processes that govern the functioning of the city could be discussed without reference to the constraining influence of spatial structure. The prevalence of this view in the field is indicated by most research studies on American cities being done in this manner. Sometimes this paradigm appears explicitly, as in the examples above, but more often we find that it is implicitly assumed. Mike Davis' otherwise excellent review in *City of Quartz* of the role of social, economic and political factors in shaping the development of Los Angeles is an example where the socioeconomic variables and political demographics of a city are analysed independently of its spatial structure (Davis, 1991).

Oddly, this paradigm would seem to conflict with the pioneering work of the Chicago School (see for example Park and Burgess' early text *The City: Suggestions for Investigation of Human Behavior in the Urban Environment*) on the regional differentiation of urban space, not only from centre-to-edge but also in terms of radial differentiation in different directions from the centre, precisely by those social and economic processes (Park and Burgess, 1931). This is a very hierarchical idea and yet there have been few suggestions that this model - derived from their studies of Chicago - can not be applied to cities in other parts of the world. Subsequently, it has been used for cities in general. The reason for these differing paradigms appears to be that this idea of the 'isotropic' grid is intuitively, rather than objectively, derived.

How different then are American cities? Hillier has suggested that they may not be so different after all, that their urban 'structure' is characterised by 'interrupted' rather than 'deformed' grids (Hillier, 1996). Structure in this sense is defined as the quantifiable difference in the syntactic values of one space in relation to all other spaces (represented as axial lines). Previous studies of other cities around the world have found that these differences appear to be systematically related to function, for example movement and land use patterns (Hillier et al, 1993; Hillier, 1996; Desyllas, 1997; Karimi, 1997). However, in the case of American cities few studies have been done.

To begin to fill this gap in our knowledge, this paper will analyse the 'metric' and 'syntactic' characteristics of a sample of American grids. Metric characteristics include quantifiable variables such as area, line length, 'segment' length and lines per square kilometre. Segment length is the line length for each space divided by the number of its connections, providing us with a rough estimate of block size, though not a definitive one (1) . The syntactic characteristics are measured using space syntax analysis. This includes established syntactic measures such as the number of axial lines (or axial size), global and local integration, connectivity, mean depth (from the most integrated line) and 'radius-radius' integration. Radius-radius integration is based on the mean depth from the most integrated line (or configuration centre). Because of this, it is a relativised measure of the degree of integration from centre-to-edge and edge-to-centre, or if you like radial integration from the centre. Also, the second order syntactic measures of intelligibility (R^2 value of the correlation between global integration and connectivity) and synergy (R^2 value of the correlation between global and local integration) are examined. This is compared to a sample of European grids. In doing so the paper seeks to answer: are the metric and syntactic variables of a sample of American and European grids comparable and, if not, how do they differ; what happens to these metric and syntactic variables as American and European grids increase in size, using metric area as the primary independent variable; and, does this tell us anything about the validity of 'isotropic grid' paradigm as a true characterisation of American urban form? If not, what are the characteristics of spatial structure in the geometrically derived cities of America, and how are they comparable to the 'emergent' global structure and differentiated local structures of European cities? (Hillier and Hanson, 1984; Hillier, 1996).

2 Researching Urban Fabrics

The sample of the paper consists of 12 American and European urban 'fabrics'. An urban fabric is an axial map which is not a 'complete' spatial model of the city, that is it models only a portion of the available spatial layout rather than the entire metropolitan area. Each urban fabric includes the 'central' area of the city, incorporating both the central business district and the historical district, whether or not these areas are coterminus. Also, each axial map is a 'distributed' model of the urban fabric where all cul-de-sacs (or one-connected lines) have been removed, leaving at least one ring of circulation available along each line. This is because the number of one connected lines is a likely difference between American and European urban grids.

Each axial map was either constructed by the author or updated from a preexisting model (which was available in the Space Syntax Laboratory urban form database of

(a) Los Angeles

(b) Miami

(c) Washington, DC

(d) Leicester

(e) London

(f) The Hague

(g) San Francisco

(h) Chicago

(i) Atlanta

(j) Amsterdam

(k) Manchester

(l) Berlin

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world cities at University College London). The 10 American urban fabrics are (in chronological order based on when the map was originally constructed): Chicago (Tremonto, 1993); St. Louis (Major, 1993); Seattle (Bottege, 1994); Atlanta (Major, 1994); Los Angeles (Major, 1994); Miami (Major, 1994); Pensacola (Major, 1994); San Francisco (Major, 1994); Washington, D.C. (Major, 1994); and Las Vegas (Major, 1995). The 10 European cities are (again in chronological order): Birmingham (Xu, 1990); Amsterdam (Xu, 1991); London (Hua Yoo, 1991); Barcelona (Xu, 1992); Leicester (Xu, 1992); Manchester (Stonor, 1992); Paris (Lee, 1992); Nottingham (Major, 1994); The Hague (Read, 1995); and Berlin (Desyllas, 1996).

At the beginning of the study, the research strategy was to construct a sample and organised in terms of axial size. Each American urban fabric was paired with an European one containing a comparable number of axial lines. In some cases axial lines were eliminated from the original model to ensure that paired fabrics had a similar number of axial lines. This was always done with reference to intuitively obvious boundaries, such as freeways or motorways, major roads or geographical features (i.e. coastline, rivers or mountains) so that each model had a clearly defined edge. This strategy was pursued at the time because it was thought that the number of lines might be an important determinant of the differences between the two samples.

However, during the course of this study it soon became clear that the metric variables were a more important determinant of the differences between American and European grids than previously realised, especially metric area. Because of this, it was decided to reorganise the sample in terms of comparable metric area. The four smallest European and four largest American urban fabrics (based on metric area) of the original 20 cities sample were eliminated and the remaining cases where reorganised into a smaller sample of 12 American and European urban fabrics (6 from each) .

The paper will proceed by presenting and analysing this sample. First, the axial maps and data table are presented. This is followed by the statistical analysis of the metric and syntactic variables for each sample using metric area as the primary independent variable. Finally, in the last section the findings of the paper are discussed and the implications for future research reviewed.

3 Formal Descriptions

Figure 1 shows the axial maps of the 12 American and European urban fabrics. Each has been set to a common scale of 1:200 000. Individual American and European urban fabrics are paired together based on comparable metric area (one above the other) and ordered from smallest to largest in two rows from left to right.

Let's begin by visually comparing the formal characteristics of the urban fabrics themselves. We can easily detect some readily apparent differences. First, we can see that the American grids are characterised by a large scale grid geometry which appears to be pervasive. In contrast, the European grids are characterised by a large scale grid deformity which also appears to be pervasive.

Figure 1 (Opposite page). Axial maps of a sample of 12 urban fabrics from the United States and Europe. Paired cases of comparable metric area are grouped together (one above the other) and the sample is ordered from smallest to largest (in two rows from left to right).

A consequence of this can be seen in the way the axial maps have been constructed

- the American axial maps are largely rectilinear whereas European are oval or circular. This is because an effect of realising formal geometry on such a large scale is longer axial lines. We can see in the American grids that some of these lines actually cross the system from edge-to-edge. This facilitates the construction of axial maps which are largely rectilinear in shape with at least one edge - and in some cases two or three - defined by a straight line. In contrast, the large scale deformity of the European grids facilitates the construction of axial maps which are approximately oval or circular in shape.

This is entirely an effect of the way we have cut out the urban fabrics from each city. If we were to model more of the urban network in the American cities - incorporating more of the surrounding suburban context - they would become more circular or oval in shape as well since this context will largely be characterised by small scale grid deformity. An example of this can be seen in Atlanta where the rectilinear nature of the axial map begins to breakdown along the northern edge.

We can also see that European grids are not completely devoid of either formal geometry or long axial lines. Long axial lines can be found in every European grid but they do not appear to be related to each other in any obvious geometrical manner. Similarly, small scale geometry can be detected in every European case but these are realised in a highly localised manner and again do not appear to be related to each other across the system as a whole in any geometrical sort of way.

Finally, we can see that every grid - American and European alike - is characterised by interruptions within the interior of the grid itself which result in 'holes' in the urban fabrics. In the American grids, these interruptions also occur along one or more of its edges and are accentuated by the relative uniformity of the rest of the grid. We can see this for example in Miami along its eastern edge which is defined by the Atlantic Ocean or in Chicago where its the eastern edge is defined by Lake Michigan. Interestingly, the formal effect of these interruptions would appear to be different for each sample - in the European grids, they further accentuate the characteristic deformity of the urban grid whereas in the American grids, they breakdown the uniformity of the geometry imposed on the urban grid.

At this point, we want to suggest that by simple visual comparison we have already taken a significant step forward in identifying some characteristic differences between American and European grids, at least formally. American grids are characterised by a formal geometry which is realised on a large scale resulting in longer axial lines. However, this formal geometry is not realised in a completely uniform manner. It is broken down in three ways: 1) interruptions within the interior of the urban fabric itself; 2) interruptions along the edges of the grid, i.e. rivers, lakes, mountains, etc... 3) the offsetting of grids whereby individual sections of grid - highly geometric in themselves - are offset to others in a non-geometrical manner; and 4) the introduction of small scale grid deformity as the city gets bigger, i.e. suburban development.

This is important because earlier we suggested that the basis of the 'isotropic grid' model was geometry. However, by simple visual inspection we can discern that the geometry in American urban grids is neither perfect nor completely uniform, i.e. it is accentuated by imperfections in, and offsets within, the urban grid. In a mathematical sense, for an object to be geometrical, and hence maintain equivalencies between locations within the object as a whole, it must be completely so (Stewart et al, 1991). It can not have a little geometry, or even a lot but possess it in complete. This is clearly not the case in American cities. At best, we can describe them as possessing geometrical characteristics. Logically then if the equivalencies between locations in the formal geometry of the object are not maintained - i.e. if the geometry is lost - then would we expect a similar absence of equivalency in its spatial structure, that is it would become differentiated. By simple visual inspection we have already demonstrated that American grids do not maintain their geometry, it is broken down by interruptions to the urban fabric and grid deformity at its edges. This means that, like European grids, they are differentiated grids, though admittedly a differing realisation.

We identified European grids as being characterised by a large scale deformity and that this deformity appeared to be relatively constant. We can say this because if we were to model more of their surrounding suburban context it seems highly unlikely that they would actually become more rectilinear, i.e. geometrical. Like American grids they possess interruptions to the urban grid which has the effect of accentuating their deformity rather than breaking down any intrinsic formal geometry. So what are we left with is two differing realisations of differentiated grids. In the next section, we will begin to explore the nature of these different realisations, what they have in common and precisely how they are different.

4 Metric and Syntactic Characteristics

Table 1 shows the data table of the metric variables for the 12 cities. The urban fabrics are organised by sample and ordered by metric area, ranging approximately from 20 to 55 square kilometres (km^2) in size, or from smallest to largest. Table 2 shows the data table of the syntactic variables for the 12 cities, which is organised in a similar manner.

Table 1. Metric data for 12 urban fabrics from the United States and Europe. The table is organised by sample and ordered in terms of metric area (from smallest to largest).

Table 2. Syntactic data for 12 urban fabrics from the United States and Europe. The table is organised by sample and ordered in terms of metric area (from smallest to largest).

If we examine the relationship between metric and axial size first, we can see that

City	Area (km^2)	METRIC k/km^2	Length (m)	Segmt (m)
Los Angeles	19.51	47.26	650.03	105
Miami	22.29	51.46	658.43	96.49
Washington DC	25.25	51.24	614.76	91.11
San Francisco	32.85	53.95	620.04	86.32
Chicago	43.89	41.44	1021.01	121.62
Atlanta	53.24	50.94	451.03	95.99
Mean	32.84	49.38	669.22	99.42
Leicester	19.68	92.96	298.01	73.92
London	25.11	140.81	286.13	61.14
The Hague	29.1	112.76	308.86	63.64
Amsterdam	34.38	118.11	282.55	59.12
Manchester	44.51	65.63	385.45	87.17
Berlin	56.3	70.41	436.45	79.21
Mean	34.85	100.11	332.91	70.70

City	K-lines	Global	SYNTACTIC CN	Local	Depth	Radius	Global/CN	Global/Local
Los Angeles	922	2.11	6.52	3.39	4.01	2.82	.42	.73
Miami	1147	2.34	6.91	3.64	3.86	3.04	.32	.77
Washington DC	1294	1.75	6.76	3.2	4.58	2.33	.35	.68
San Francisco	1772	1.37	6.58	3.06	5.67	1.99	.23	.57
Chicago	1819	3.09	8.56	4.27	3.41	4.27	.47	.86
Atlanta	2712	1.39	4.78	2.7	5.83	1.9	.23	.56
Mean	1611	2.01	6.69	3.38	4.56	2.73	.34	.69
Leicester	1829	1.05	4.31	2.47	7.14	1.5	.12	.3
London	3536	1.25	4.89	2.73	6.46	1.9	.17	.37
The Hague	3282	1.31	4.91	2.72	7.88	1.89	.22	.46
Amsterdam	4060	.87	4.9	2.69	9.17	1.44	.16	.28
Manchester	2921	1.01	4.68	2.59	7.5	1.54	.16	.33
Berlin	3964	1.19	5.87	3	6.86	1.77	.15	.29
Mean	3265	1.11	4.93	2.7	7.50	1.68	.16	.34

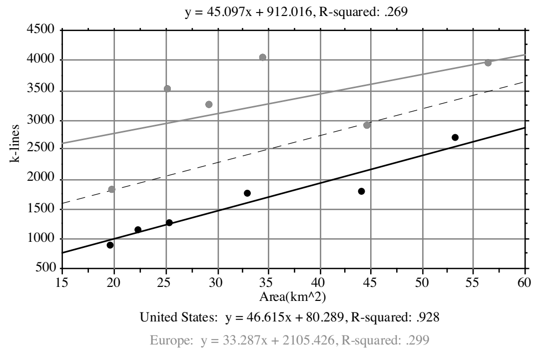

Figure 2. Regression of metric area (km^2) against the number of axial lines in the sample of 12 American and European urban fabrics.

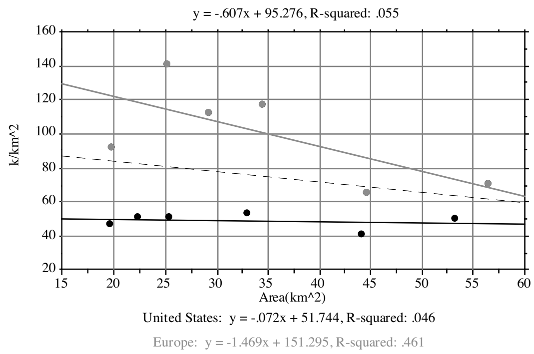

Figure 3a. Regression of metric area (km^2) against the mean number of axial lines per km^2 in the sample of 12 American and European urban fabrics.

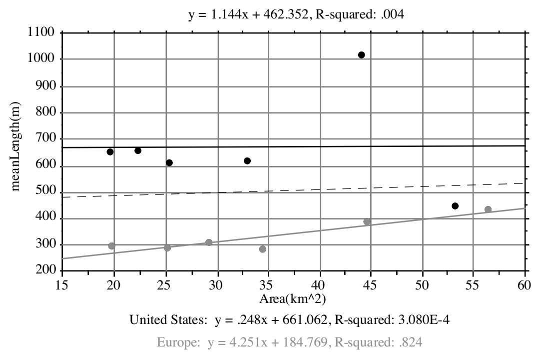

Figure 3b. Regression of metric area (km^2) against the mean metric length of axial lines (metres) in the sample of 12 American and European urban fabrics.

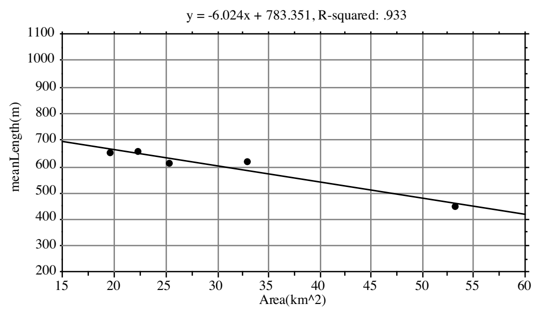

Figure 3c. Regression of metric area (km^2) against the mean metric length of axial lines (metres) in the American sample without Chicago.

though the average area of the two samples is nearly equivalent (American: 32.84; European: 34.85), the average number of axial lines is significantly higher in the European sample (3265 compared to 1611). Looking at the metric variables, we can also see that the average number of axial lines per km^2 in the European sample is significantly higher (100.11 k/km^2 compared to 49.38 k/km^2) whereas the average line length (in metres) is less than half (332.91m and 669.22m). Finally, the average street segment in the American sample is nearly 40% longer (99.42m and 70.70m).

Turning our attention now to the syntactic data in Table 2, the average global integration in the American sample (2.01) is nearly twice that of the European (1.11), whereas average connectivity is about 35% higher (6.69 and 4.93). Average local integration in the American sample is 25% higher (3.38 and 2.70). Finally, average radius integration in the American sample is over 60% higher (2.73 and 1.68) whereas the average depth from the most integrated line is 60% shallower (4.56 and 7.50) (2).

This initially provides a compelling picture of the differences between American and European grids of comparable metric area. American grids are characterised by few lines which tend to be long, making them highly connected and the grid axially sparse. This is accentuated by larger blocks. This means they are highly connected systems. The effect of this is to strengthen global and local integration across the system, shallowness from the most integrated line in the grid and, because of this shallowness, radial integration from edge-to-centre-to-edge. On the other hand, European grids are characterised by many lines which tend to be short, making the grid both less connected and axially dense. This is accentuated by smaller blocks. The effect of this is they are not as globally or locally integrated as the American grids and possess more depth from the most integrated line in the grid. Because of this, they are not as integrated radially from edge-to-centre-to-edge.

One consequence of this can be seen in the second order measures of intelligibility and synergy. We can see that on average American grids are twice as intelligible as European grids. This is also true for the measure of synergy. One might ask does this have a pervasive effect on how they get bigger. In the next section we will examine this by analysing what happens to American and European grids as they grow larger.

5 The Consequences of Size

In this section, we will analyse the metric and syntactic characteristics of the samples using metric area are the primary independent variable. This is done to objectively discuss what happens as American and European urban fabrics get larger, i.e.

are there any obvious patterns and are the samples in any way comparable? In each correlation, the American cases are shown as black dots whereas the European is shown in grey. The slope of correlation for each individual sample is also shown as a black or grey line respectively. The R^2 values for each sample is also shown in black and grey below the correlation. The slope of correlation for the 12 urban fabrics as a whole is shown as a dashed line and its R^2 value is shown at the top of the diagrams.

Figure 2 shows the correlation between the number of axial lines and the metric area. We can see that there is an extremely strong relationship between axial size and metric area in the American sample (R^2= 0.928) whereas the correlation for the European sample is insignificant (R^2 = 0.299) though there is clearly a positive trend to the distribution. We can see that the slope of correlation for each sample 'mirrors' the other, that is they follow the same slope, though in different parts of the range. For example, the slope begins around 750 lines for the American sample and 2500 lines for the European for a metric area of 15 km^2, or a ratio of 1-to-3. The slope ends around 2800 lines for the American sample and 4200 lines for the European sample for a metric area of 60 km^2, or a ratio of 1-to-1.5.

Figure 3a shows the correlation between the number of axial lines per km^2 and metric area. The correlations for both samples is insignificant though European sample is only slightly so. What is striking about these correlations is the distribution of each sample: the American sample 'flatlines' around 50 lines per km^2 whereas the European is more clearly negative, i.e. as they get larger the number of lines per km^2 decreases. Figure 3b shows the correlation between the mean line length and metric area. We can see that the correlation in the European sample is strong and significant (R^2 = 0.824), i.e. as they get larger their average line length gets longer. The correlation in the American sample for insignificant. However, if we examine it more closely we can see that it is distorted by one case where the average line length (over 1000m) is extremely high for its metric area - Chicago. It would appear that the general trend in the American sample, if not for Chicago, would be negative, i.e. as they get larger the average line length gets shorter. We can see this more clearly in Figure 3c which shows the correlation between line length and metric area without Chicago. The trend in the American sample is now strongly negative and significant (R^2 = - 0.933). The last of the metric variables can be examined in Figure 3d. It shows that the correlation between segment length and metric area is insignificant in both of the samples, and that there does not appear to be any distinct pattern to the distributions.

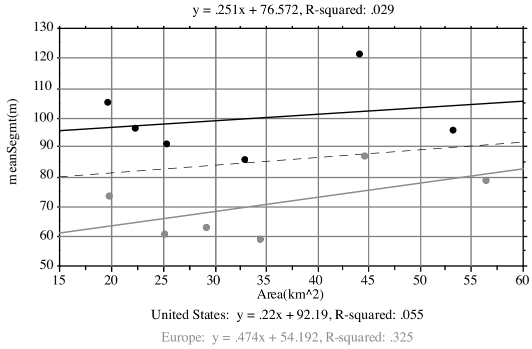

Figure 3d. Regression of metric area (km^2) against the mean segment length (metres) in the sample of 12 American and European urban fabrics.

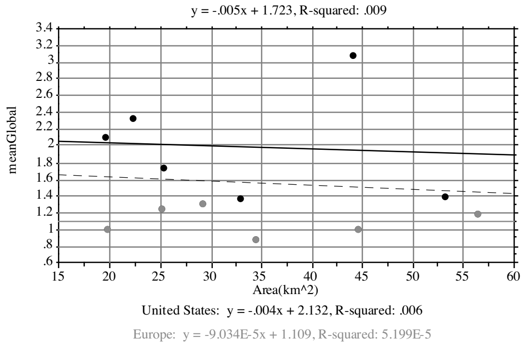

Figure 4a. Regression of metric area (km^2) against the mean global integration in the sample of 12 American and European urban fabrics.

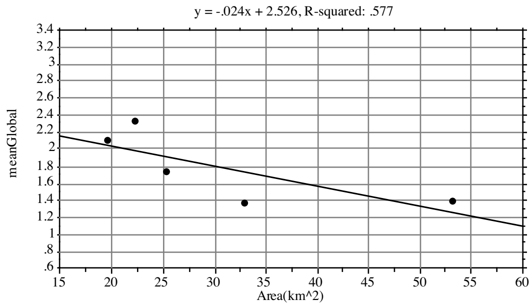

Figure 4b. Regression of metric area (km^2) against the mean global integration in the American sample without Chicago.

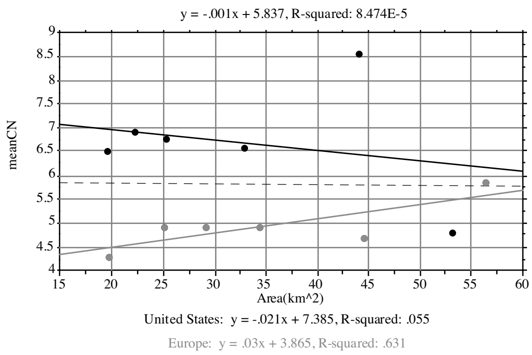

Figure 4c. Regression of metric area (km^2) against the mean connectivity in the sample of 12 American and European urban fabrics.

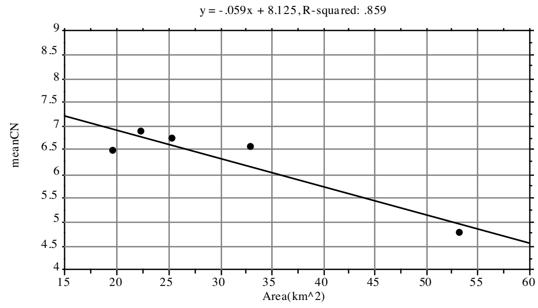

Figure 4d. Regression of metric area (km^2) against the mean connectivity in the American sample without Chicago.

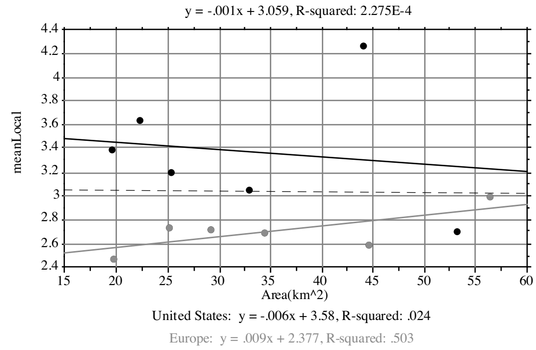

Figure 4e. Regression of metric area (km^2) against the mean local integration in the sample of 12 American and European urban fabrics.

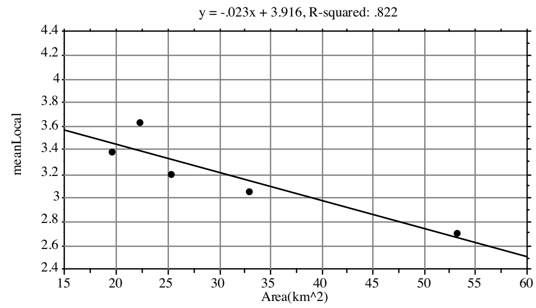

Figure 4f. Regression of metric area (km^2) against the mean local integration in the American sample without Chicago.

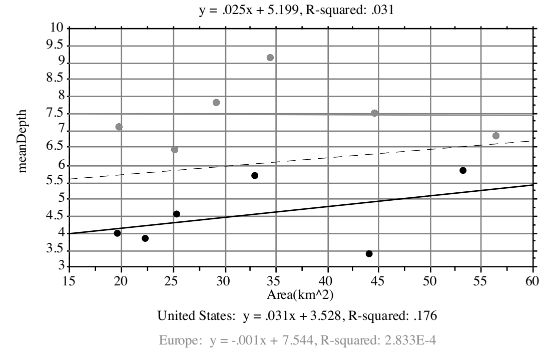

Figure 4g. Regression of metric area (km^2) against the mean depth from the most integrated line in the sample of 12 American and European urban fabrics.

Figure 4a shows the correlation between mean global integration and metric size. We can see that the correlation is insignificant in both samples. The European sample clearly 'flatlines' around a mean global integration value of 1, whereas the distribution in the American sample would again appear to be negative but for the effect of Chicago. We can see this is true in Figure 4b which shows the correlation between metric area and mean global integration without Chicago. The trend is negative and significant (R^2 = - 0.577), that is as American grids get larger their mean global integration decreases. This suggests that the previous findings of Hillier et al that there is no relationship between global integration and size does not hold true for American cities (Hillier et al, 1987), at least when metric area is the variable for size. Figure 4c shows the correlation between mean connectivity and metric size. There is a strong and significant relationship in the European sample (R^2 = 0.631), i.e. as they get bigger they become more connected. In the American sample there again appears to be a negative trend but for the distortion of Chicago. If we examine this correlation without Chicago (see Figure 4d) we can see that the trend is, in fact, strongly negative (R^2 = - 0.859), that is as American grids get bigger they get less connected. Hillier et al were able to show in 1987 that there is a relationship between axial size and mean connectivity in settlements, that is as the axial size increases so does the mean connectivity (Hillier et al, 1987). This relationship appears to be different in American cities.

Figure 4e shows the correlation between mean local integration and metric area. The correlation for both samples is similar to mean connectivity (see Figure 4c). This is not surprising since they are both 'local' measures and always strongly related to each other (Hillier et al, 1987). There is a clear, positive relationship in the European sample (R^2 = 0.503) whereas the trend in the American sample appears to be negative, again if not for the effect of Chicago. Figure 4f shows the correlation without Chicago. We can see that - as with mean connectivity - the trend in the American sample is strongly negative (R^2 = - 0.822) without Chicago. Figure 4g shows the correlation between mean depth (from the most integrated line) and metric area. There is no relationship between depth and metric area in the European sample whereas the trend in the American sample appears to be positively correlated, again but for the effect of Chicago. Figure 4h confirms this as the American sample is strongly and positively correlated (R^2 = 0.745) with Chicago removed, i.e. as they get larger they get deeper from their most integrated line. Figure 4j shows the correlation between mean radius integration and metric area. The correlation for both samples is insignificant. The European sample 'flatlines' around a mean radius integration of 1.75 whereas the trend in the American sample would appear again to be negative without Chicago. Figure 4k shows the correlation with Chicago removed. We can see that the trend in the American sample is negative and significant ($R^2 = -0.641$), that is as they get larger the degree of radial accessibility from edge-to-centre-to-edge decreases.

The picture of the differences between the American and European urban fabrics now becomes clearer. As American grids get bigger the number of axial lines increase at a faster rate though the formal composition of the urban grid remains largely stable, hence the number of axial lines per km^2 is invariant. This could indicate that block size in American grids are relatively uniform. Siksna's comparisons of American and Australian urban blocks sizes could be seen as supporting this notion. (Siksna, 1997). Since we know that American grids utilise formal geometry on such a large scale, this would makes intuitive sense. However, as they get bigger their mean line length becomes shorter and they become less connected. They start off highly locally integrated when they are small and become less so as they get bigger. Finally, they become deeper from their most integrated line and less radially integrated the larger they become. For European grids the picture is quite different. As they get bigger the number of axial lines increase at a slower rate and the formal composition of the grid becomes more sparse, hence the number of axial lines per km^2 becomes less. This indicates that block size in European grids gets larger as the city grows. Also, as they get bigger their mean line length gets longer and they become more connected. They also become more locally integrated as they get bigger. Finally, in contrast to the American sample their initial degree of global integration, mean depth from the most integrated line and radial integration appear to be remain stable as they get larger.

We can examine the effects of this on intelligibility and synergy in Figures 5a and b. They show the correlation between metric area and intelligibility and synergy respectively. We can see first, that the correlations of the European sample exhibits a 'flatline' distribution and second, that the correlations of the American sample would again appear to be negative but for the distortion of Chicago. If we remove Chicago from the correlation as before we can clearly see the negative trend for both second order measures (intelligibility $R^2 = -0.637$; synergy $R^2 = -0.688$) (Figure 5c and d) in the American sample.

Having now review the relationship of metric area with the metric and syntactic variables, we are now in a position to hypothesis what may be the prime determinant of the spatial pattern of American and European urban grids. We can answer this question by asking: what remains stable as they grow? We have seen that in the case of the American urban grids the only constant was the formal

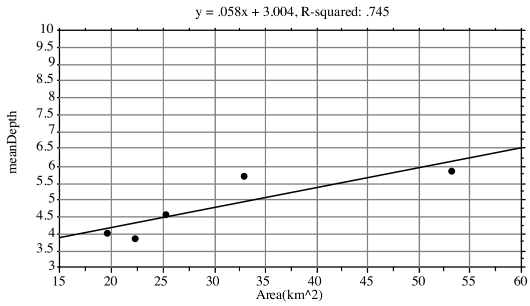

Figure 4h. Regression of metric area (km^2) against the mean depth from the most integrated line in the American sample without Chicago.

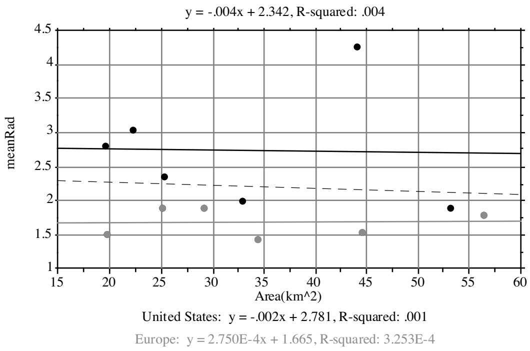

Figure 4i. Regression of metric area (km^2) against the mean radius integration in the sample of 12 American and European urban fabrics.

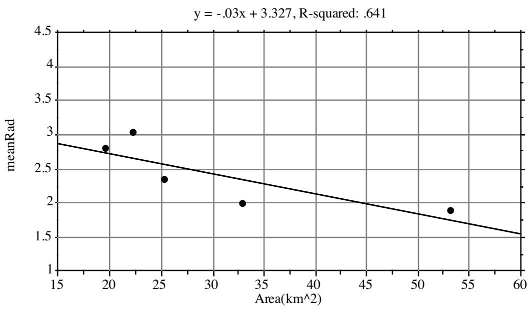

Figure 4j. Regression of metric area (km^2) against the mean radius integration in the American sample without Chicago.

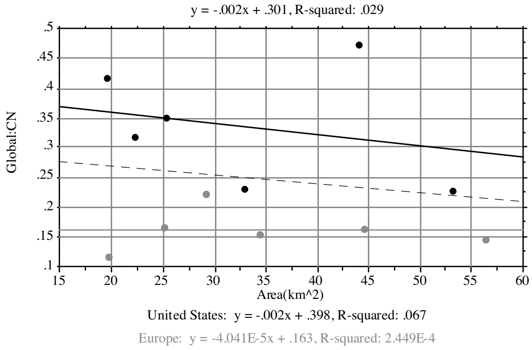

Figure 5a. Regression of metric area (km^2) against intelligibility (R^2 value of the correlation between global integration and connectivity) in the sample of 12 American and European urban fabrics.

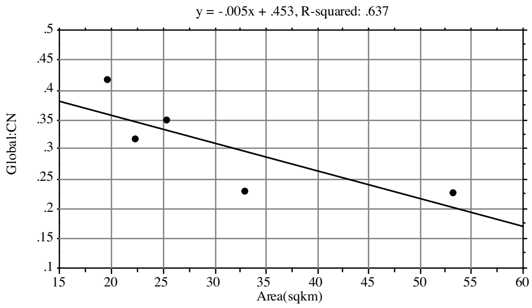

Figure 5b. Regression of metric area (km^2) against intelligibility in the American sample without Chicago.

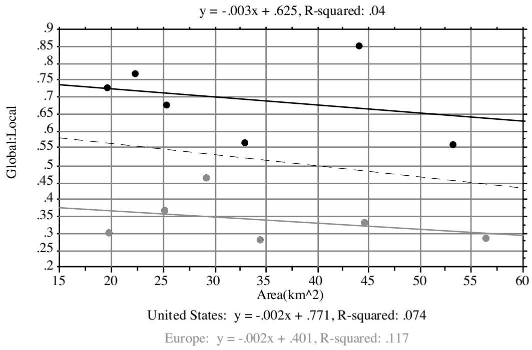

Figure 5c. Regression of metric area (km^2) against synergy (R^2 value of the correlation between global and local integration) in the sample of 12 American and European urban fabrics.

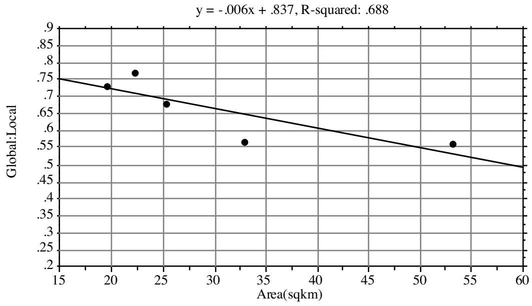

Figure 5d. Regression of metric area (km^2) against synergy in the American sample without Chicago.

composition of the grid as defined by the number of axial lines per km^2 and the segment length (and by implication, block size). In the case of the European grids it was global integration, mean depth from the most integrated line and the degree of radial integration, which clearly impacts on the relative stability of intelligibility and synergy. In the next section we will discuss what this might mean.

6 The Grid Logic of American and European Cities

Previously we saw what appeared to be a systematic pattern to the way the metric and syntactic variables in the American and European samples were related to size. In the American sample this pattern was negative for most variables, that is as they got metrically larger American grids tended to become less globally, locally and radially integrated, and less connected as line length became shorter. In the European sample the trend was positive for the most variables, that is as they got metrically bigger they tended to become more connected and locally integrated, as line length became longer and the grid became less axially dense. The block size also appeared to get larger. This would suggest an almost opposite pattern. Why should this be the case? We would suggest that it is because these patterns are largely determined by the initial conditions of the grid.

When they are small, the formal geometry of the American grid is at its most pervasive. This results in them initially being much more globally integrated with much longer lines which are much more connected and locally integrated. Also, because lines are longer the grid as a whole is that much more shallower from the configurational centre, hence they are much more radially integrated. In contrast, when they are small the effect of grid deformity in the European grid is at its most pervasive. They have shorter lines which are less connected and locally integrated, and they utilise smaller blocks. The initial conditions intensifies if you like the differences. This intensification is a direct result of formal geometry and grid deformity in American and European grids when they are small.

However, because the metric and syntactic variables in the American sample are, for the most part, negatively correlated they tend to lose more and more of what they have as they become larger. Again in contrast, because most of these variables are positively correlated in the European sample they tend to gain more and more of what they did not initially possess. This suggests that as American and European grids get bigger their metric and syntactic variables begin to approximate each other. This answers in part one of the questions of this paper - how are they different? The evidence would suggest when they are small they are quite different but when they are large they are not as different as one might expected. In fact, when they are big, they are quite similar. The question now becomes why?

We would suggest that the answer lies in those metric and syntactic variables which do not correlate with size. In the European grids we saw that global integration, mean depth from the most integrated line and radial integration were either stable (as in the case of global and radial integration) or insignificantly correlated. We saw that an effect of this was that the second order measures of intelligibility and synergy in the European sample were also insignificantly correlated with size (with the R^2 value of intelligibility being almost constant around an 0.15). In contrast we saw that in the American sample the number of lines per km^2 was stable when correlated with metric area and that street segment length was insignificantly correlated. In other words, key syntactic variables related to the overall shallowness of the city, especially from centre-to-edge, are more or less maintained in European grids as they get bigger whereas in American grids it is the purely formal measures which are maintained. This means as they get bigger spatial pattern is maintained in European grids whereas formal composition is maintained in American grids.

We have to add a caveat here. Remember that we are dealing with urban fabrics rather than whole urban systems, essentially what could be thought of as 'cut outs'. This finding is tailored to the initial way in which the sample was constructed. While it would appear to be true, it is only so until to a certain point of expansion. Undoubtedly as American grids get larger this maintenance of their formal geometry begins to breakdown (remember the example of Atlanta earlier). The introduction of suburban grid deformity at their edges will certainly have the impact of increasing the number of lines per km^2. It also seems likely that the block size will become larger and positively correlated since development at the edges of any city will tend to be less uniform and dense. The edges of cities are often characterised by large stretches of vacant land in the suburban fringe which will serve to dramatically increase average block size. This will have the impact of making the findings above - about maintaining the formal geometry of the American grid - only true up to a certain size but it will reinforce the tendency for the metric and syntactic variables in American and European grids to become more similar as they increase in size.

7 Conclusion

The paper has taken only a small step to beginning to quantify the differences between American and European cities, however we would suggest that this represents an important first step. The findings of the paper would seem to indicate that American grids are structured and differentiated rather than purely geometrical objects. It was suggested that a fundamental characteristic of American urban grids is that the formal composition of the grid is maintained as they increase in size (though only until a certain size) whereas spatial pattern is maintained in European urban grids as they increase in size. Despite this, it was argued that a primary differences between American and European urban grids is that the formal geometry and grid deformity respectively in each serves to intensify the initial differences between them but as they get larger, the differences in spatial structure becomes less pronounced. This would appear to have important implications for research about American cities because it suggests that the adoption of the 'isotropic grid' paradigm for investigating the social and economic characteristics of American cities may not be a valid since researchers will not be able to 'control' for the variable of spatial layout in differentiating cause and effect. However, more research is needed before we can conclusively answer this question.

Notes

(1) A more rigorous measure would be to multiply this segment length by the average number of block facades but, unfortunately, this data is not available.

(2) These discussions of integration values being so much of a percentage higher or lower in one sample in comparison to another is a 'false quantification' in that the numbers themselves do not actually mean anything. However, quantifying the differences in integration values between two samples in this manner is the simplest way to describe these differences.

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