IS NEIGHBOURHOOD MEASURABLE?

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**Abstract**

The production of social outcomes such as neighbourhood has been an architectural and urban design goal dating back to the work of Perry (Perry 1998) and remains a stated objective today with groups such as New Urbanists (Katz 1993) and Urban Village (Huxford, 1998; Neal, 2003) designers. In this paper the author introduces new work extending the concept of intelligibility and synergy introduced by Hillier (1996). The paper shows how a local correlation method can be used to produce point intelligibility and point synergy. The paper goes on to show why it is convenient to replace the radius mechanism with the vicinity mechanism to achieve consistent results. The paper highlights that these axial point intelligibility and point synergy values appear to be nearly uniform across a named neighbourhood and that they can therefore be used as a means of identification purely from the axial models commonly used in space syntax. The paper produces empirical data from Hampstead Garden Suburb and Brentham Garden Suburb demonstrating that the use of point synergy and point intelligibility are consistent with the average bounds produced by surveying neighbourhood inhabitants. This paper concludes that, although further investigation is called for, this method is evidence that spatial design appears to have causative effect on the formation of neighbourhoods.

**Introduction**

The production of place and/or neighbourhood has been a central concern for architects and urban planners. While a number of theories abound on the prerequisite design elements to facilitate neighbourhood, there has to date been few objective studies on the design elements necessary to foster neighbourhoods (Lynch [1960] being the notable exception). The extent of this gap in research is emphasised by the doubt in some circles that, being a environmental factor, space has any prior or causative relation to a social phenomena (Talen 1999, 2000). This gives rise to the central question of this paper, does space and hence design, have any influence on the shape and production of neighbourhood or is neighbourhood and place purely a social product? The hypothesis of this paper is that...
space is influential and that it is possible to identify areas of potential neighbourhood without recourse to social records.

In ‘Space is the machine’, Hillier (1996) identifies well formed neighbourhoods as having specific configurational properties and as such it could be argued that the structure of space influences the character of a neighbourhood beyond simply guiding movement patterns. One argument against the Hillierian view is that neighbourhoods are themselves quite vaguely defined entities existing in an apriori form. One might argue that the zone used to define a neighbourhood is purely based upon concepts handed down from higher authorities and defined according to beaurocratic convenience. It might be argued than that, as a purely artificial phenomenon, configurational regularities are simply random artefacts. For example, one might imagine a future Napoleon-like figure taking over London and imposing a neighbourhood pattern based on a strictly regular grid. One’s neighbourhood would then become the appropriate grid in one’s A-Z map. By experimenting with this form of neighbourhood, the regularities described become much more random in appearance. From this point of view, simply by creating a name for a design project, then imposing it, neighbourhood can be created.

Countering this notion of place, we have the reverse concept of neighbourhood as an emerged property. That is, there is some property or properties of a particular location that give rise to a location based shared identity. This identity forms the basis for the neighbourhood. Notice that location is an important basis for this identity. In this paper, we will differentiate between a neighbourhood and a community. A community can exist independent of space; for example, a Muslim community or a Star Trek community can exist together but do not necessarily need to live in the same location. In effect we can have community without propinquity (Webber 1963), for this paper a neighbourhood is predicated on some kind of spatial co-presence.

The neighbourhood as an emergent property suggests there is some resemblance of a natural neighbourhood, a region that spontaneously arises. This region can be co-opted by government or estate agents for their own ends but is based on some shared intangible notion of neighbourhood. If such a natural neighbourhoods exist then it would be possible to perform the type of analysis Hillier describes and find the results enlightening.

It is the thesis of this paper that these natural neighbourhoods exists to some strong degree and that the primary property that defines their existence is the configuration of space. In ‘Space is the Machine’, Hillier (Hillier 1996) introduces two measures of the overall configuration of the urban grid and it is from these measures that we shall begin the investigation of neighbourhood.

The first measure is that of intelligibility. The intelligibility of a system is defined as the correlation between the integration and connectivity of the axial lines/nodes in that system. Intelligibility can be interpreted in a number of ways. Firstly Hillier describes it as ‘the property of intelligibility of a deformed grid meaning that the degree to which what we can see from the spaces that make up a system is a good guide to what we cannot see, that is the integration of each space in the system as a whole’. The measure of intelligibility suggested by Hillier agrees remarkably well with our intuition of a labyrinthine layout. It would then make sense to consider intelligibility as a neighbourhood property to be intuited from the perspective of the ground. This property requires the inhabitant to move repeatedly through the space building some kind of mental impression.
The second measure is Synergy that describes the part, or whole property of a neighbourhood. Synergy is a measure of the correlation between the radius 3 integration and radius infinity integration. This measure reflects how the global structure of an entire entity like a city or city region is reflected in the local structure of space. Again, to quote Hillier (1996) ‘Research has shown that the critical thing about urban sub-areas is how their internal structures relates to the larger-scale system in which they are embedded’. In this paper, we generalise the concept of synergy to refer to the correlation between a value of radius X against a value of radius infinity. By convention, we will take general synergy as a reflection of the radius parameter and reserve synergy to refer to the more specific case of radius 3, radius infinity correlation.

**Method**

If we do not know the boundary of an area prior to finding the value of intelligibility or synergy then how might we define a measure that implicitly needs the boundary? The heart of the new method is to find a synergy point. To understand this, we need to realise that when selecting a neighbourhood, we are selecting a sub-area of the system in question. More specifically, we are selecting a sub-set and processing the values for that set. From this point of view, we can use any method to select a sub-set and discover the intelligibility and general synergy values for that sub-set. The sub-areas in the presented case were chosen on a geographic basis (a continuous area was selected within geographically defined bounds). We are not confined to select on this basis and are free to select any arbitrary subset of the graph. For example, we can begin by randomly choosing a starting node and then find the sub-graph by selecting all the lines that lie within three steps (three changes of direction) from that starting point. This sub-set we will call the locality set around a fixed axial line/node. This selection process is analogous to finding the integration within a fixed radius. By finding the local correlation for this sub-graph we determine a value (r squared) between 0.0 and 1.0 where 1.0 reflects a perfect correlation (either positive or negative) between the integration and connectivity (degree) for each selection node, and a value of 0.0 indicates no (or a random) correlation. This value can then be attributed as a property for the axial line/node in question. This gives a value called the point synergy for a node. This process can then be repeated exhaustively for each axialline/node in a system as a starting point.

**Figure 1:**
Plot of point intelligibility for the Kingscross area - problem line in circle
Figure 1 shows an axial map indicating the values of the point intelligibility. Two observations can be made at this point. Surprisingly it appears that all the axial lines in the neighbourhood have similar point intelligibility values. It is also clear that certain remote lines (circled in figure 1) have incredibly high point synergy factors. Investigating these lines, it is clear that what is in fact happening is that the small number of lines within a fixed radius is of low significance in statistical terms. When a segregated axial line has a small locality set then it is quite possible that the values will produce intelligibility correlation of 1 or -1.0 (imagine a locality set with only 2 lines/nodes will have a perfect correlation). It can be seen that this small locality set problem can be seen as a specific incidence of having a flexible size of set. It is known that it is harder for a larger number of axial lines/nodes to have a strong correlation.

To help eliminate this variability there are a number of solutions. One crude solution is to eliminate all spaces that fail to have a minimum number of nodes. This eliminates the problem of unrepresentative size but does nothing to tackle cases where the set is much larger than normal. An alternative is to implement the ‘vicinity’ method described by the author in Dalton (2005). The concept of vicinity was originally created to deal with the problem of general relativisation of a sub-graph when trying to create a system of relativisation that could be applied to both topological integration and axial angular integration systems. The author’s proposal was that instead of trying to normalise the total depth of a locality set for the number of lines, it might be simpler to fix the size of the set to some small value. By removing the variability, size of the locality set the necessity to relativise the total depth value is removed. While not a complete or a perfect solution the paper suggests that this value might be a surfactant to permit cross comparisons and allow the testing of new relativisation methods in angular systems. To implement the vicinity value for topological values it is necessary to sort the depth values in order. For a system of vicinity 10 then the first (smallest) 10 depth values are chosen. If we consider a small system with a sorted list of node step depths $D$ as

$$D = \{0,1,1,1,2,2,2,2,2,3,3,3,3,3,4,4,4,4,4,4,4,4\}$$

we can see the radius 3 locality as

$$R_3 = \{0,1,1,1,2,2,2,2,2,3,3,3,3,3,\}$$

The vicinity 10 set would be

$$V_{10} = \{0,1,1,1,2,2,2,2\}$$

One common confusion arises from the often-made observation that in the above case there are 7 axial lines/nodes with depth 2 and in the vicinity case only 5 are chosen. Surely the choice of node is arbitrary. It should be obvious in the above depth-based example that the choice of radius 2 node is arbitrary but the contribution to the total depth for any node at radius 2 is identical. That is, all orders of 5 axial lines/nodes at depth 2 from the 7 choices will always contribute a total depth of 10 ($2^5=10$), for any and all combinations of axial lines/nodes. It should also be observed that the same system could be used to create a locality subset for axial lines nodes ordered by degree of angular depth from the start. From experiments it has been found that for a case of 89 axial maps covering a number of urban systems a value of Vicinity = 90 correlated well with the value of integration radius 3.

We can use the vicinity concept to capture a sub-set of axial lines/nodes around a selected starting node. If we consider nodes sorted by topological depth we can create a correlation coefficient that will be comparable and, from a statistical point of view, always be
valid. If we plot the same axial map by point intelligibility we can see that these values and therefore colours are consistent and do not have the stark glitches found in the radius case. Notice that this introduces a vicinity value that can be used as a parameter to the point intelligibility measure. Observe that when \( V = N \) then every axial line/node will have the same intelligibly value, which will be that of the system.

A radius based or a vicinity based locality set can be applied to find the synergy correlation and produce a point synergy map. We can produce a second visualisation of the values and present them in Figure 2. From this figure we can make two observations, firstly that the neighbourhood patterns are similar to those found in the intelligibility case. Given that the methods used to determine these patterns are different from each other is reassuring. Secondly the clarity of the region is clearer in the point synergy case suggesting that neighbourhood is a ‘part-whole’ phenomena.

In Dalton (Dalton 2006) the author presents the neighbourhood finding methods described above and presents the case from Lynch (Lynch 1960) called Beacon Hill. In this example we find that the two informal sub areas of Beacon Hill, known as ‘Front side’ and ‘Backside’ or ‘Northside’ and Southside, appear at Vicinity = 90 for both point intelligibly and point synergy mapping. The paper goes on to show that the larger area of Beacon Hill is not awarded a value of near constant point synergy. If however, we process the map using radius 4, and radius infinity synergy values with a vicinity value of 180, then the area known as Beacon hill emerges. While not a definitive test, the capability to reflect the nested hierarchical nature of named sub-areas suggests that this method successfully reflects the conceptualisation of neighbourhoods. This result also reflects the possibility that the point intelligibly and point synergy mapping methods can be used in a non-European context.

**Testing**

Unfortunately the Lynch (1960) data is the only readily available data that has undergone systematic research for the local inhabitant’s impressions of neighbourhood boundaries. The rest of this section is concerned with the two types of tests performed. The first test is a longitudinal one, which looks at a number of differing UK cities and tests to see if the neighbourhood finding methods can be applied to these cities. The second test attempts to reproduce a Lynch like approach to local boundary definition and then test the area finding method against it.
The first method is relatively simple and quite broad. While not being definitive it does provide a mechanism to quickly dismiss any neighbourhood finding method. This test relies on the fact that in the UK named neighbourhoods are occasionally presented as names on the Ordinance Survey Maps (Survey, 2006). That is if a neighbourhood name appears on a map, then it is fairly sure that some kind of neighbourhood exists. This does not imply that if an area does not have a name on the map that the local inhabitants do not perceive some sense of neighbourhood and may well have a name for their sub area. To perform the test the locations of named areas were taken from Ordinance Survey maps and applied to an area on the map. The weakness of this method lays in the absence of a firm boundary derived from the Ordinance Survey maps. A circle was drawn on a point synergy axial map where the named neighbourhood appeared on the map. The size of the circle was roughly inferred from the size of the named area on Ordinance Survey map. This would create a number of circles for a number of different cities. Each circle was then judged to be empty or contain an area of near constant or point intelligibility point synergy. The successes and failures are presented in table 1 below. It should be noted that in the case of Wolverhampton six of the named zones that failed to be identified were villages on the edge of the city that were in the process of being surrounded by the city. In other cases named areas had been imposed, for example Oxford had an area called the Oxford Leys estate that clearly had two separate regions of continuous point synergy reflecting the build phases of the project. This is a case of the top down planning process imposing a name on the project rather then the name potentially reflecting the inhabitants’ perception of place.

<table>
<thead>
<tr>
<th>City</th>
<th>Measure</th>
<th>Correct</th>
<th>Incorrect</th>
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<tbody>
<tr>
<td>Oxford</td>
<td>synergy</td>
<td>21</td>
<td>4</td>
</tr>
<tr>
<td>Wolverhampton</td>
<td>synergy</td>
<td>39</td>
<td>12</td>
</tr>
<tr>
<td>York</td>
<td>synergy</td>
<td>14</td>
<td>1</td>
</tr>
<tr>
<td>Bristol</td>
<td>synergy</td>
<td>34</td>
<td>11</td>
</tr>
<tr>
<td>Cambridge</td>
<td>synergy</td>
<td>8</td>
<td>0</td>
</tr>
<tr>
<td>Norwich</td>
<td>synergy</td>
<td>16</td>
<td>2</td>
</tr>
<tr>
<td>Newcastle</td>
<td>synergy</td>
<td>23</td>
<td>9</td>
</tr>
<tr>
<td>Manchester</td>
<td>synergy</td>
<td>8</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>163</td>
<td>39</td>
</tr>
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</table>

It can be seen from the above method that any accurate test depends upon an accurate boundary defined by the local inhabitants. The second testing methodology is derived from that used by Lynch (see appendix 2 of the Image of the City). In Lynch’s method local inhabitants were interviewed and as part of the interview, invited to draw a map of the locality with the boundary of their neighbourhood imposed above it. Given that the primary research question was the boundary of the neighbourhood it was possible to use a simpler method. In this case a free return A5 postcard was put through the letterbox of a number of predefined areas in London. The card contained a map of the area. To avoid biasing the centre the map was partially moved off centre of the card revealing different areas to the north, south, east and west. The card also contained a short note briefly explaining the purpose of the research and requesting the recipient to draw the outline of what they considered the neighbourhood. It was felt from other research being carried out that many respondents could not read a map. To check this, the respondent was requested to tick the street they lived on. This was then compared to an invisible line drawn on the street of delivery using an ultraviolet marker pen. Along with the map, the participant...
was requested to state if they considered them selves a local, the name of their neighbourhood and roughly how many households they considered they knew.

In this case the data will be presented for Hampstead Garden Suburb and Breanham Garden Suburb where 300 cards were posted. There were 12 respondents for H.G.S and 11 for B.G.S. Figure 3 shows a map with the combined boundaries for all of the appropriate respondents for H.G.S in Figure 3 and b) B.G.S. shows the corresponding axial maps showing point synergy for each case with the official boundaries shown. It can been seen in the case of H.G.S that while there is a large metric area, there is a considerable degree of agreement on the extent of H.G.S principally being the east boundary of Golders Green and the northern boundary of Finchely Rd. The centre of H.G.S also comprises a large area of common agreement. In the case of B.G.S we find that the area of overlap is considerably less significant even when allowing for the smaller metric area of B.G.S. It is not insignificant to observe that while 95% of all
respondents in H.G.S but only 60% of respondents in B.G.S correctly identified their neighbourhood. This suggests that B.G.S residents had a vague perception of their neighbourhood compared to those in H.G.S.

Figure 5: Intersection with radials to compute average bounds

We can test the results of the synergy mapping in a number of ways. Firstly we can find the average boundary of the respondents. To do this an origin point in the common overlap of all the respondents’ neighbourhood boundaries is chosen as the centre of a radial. A number such as 360 is selected and this number of evenly distributed radials is drawn out from the origin point. A single radial will intersect all the respondents’ neighbourhood boundaries at a radius from the origin along the line. These radius values can then be mathematically manipulated. Specifically, the average radius can be found along with the standard deviation see figure 5. This process can be repeated for all radials forming average radial points that can be linked together to form an average neighbourhood polygon. The individual standard deviations along a line can also be used to plot a curve of one and two standard deviations along the radial. These lines are useful to determine what parts of the boundary are commonly agreed upon and those where disagreement are common. Figure 6 and figure 7 show a plot of the average curves for Hampstead Garden and Breanham Garden Suburbs respectively.

If the hypothesis, that regions of constant point synergy describe real world neighbourhoods, were true then we would expect a consistent range of point synergy values within the average neighbourhood boundary. Visually if we see that there is a consistent colour within the bounds and differing colours exists beyond the average neighbourhood boundary then we would regard that result as consistent with the hypothesis that the values of point synergy and point intelligibility are identifying the natural neighbourhood of the areas within question. Statistically we expect to find a smaller standard deviation of values than the surrounding values. We would also expect to find some difference in the average value of point synergy and point intelligibility compared to the surrounding values. It should be noted that we are not expecting a perfect consistency of values within the neighbourhood. This is due in no small part to the
length of axial lines. If an axial line enters or penetrates the average
eighbourhood boundary then its’ value might well not be constant
with that of the neighbourhood in general. This can be attributed to the
length of the axial line. Some future mechanism might be based on a
more segmental approach and as such we might then legitimately
expect to determine a space more consistent within a neighbourhood.

**Figure 6:**
Map of B.G.S coloured by
Point Synergy V=90

**Figure 7:**
Map of H.G.S coloured by
Point Synergy V=90
Results

<table>
<thead>
<tr>
<th>Where ?</th>
<th>Brentham GS</th>
<th>Hampstead GS</th>
<th>Hampstead GS</th>
<th>Hampstead GS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measure</td>
<td>Point Synergy</td>
<td>Point Intelligibility</td>
<td>Point Intelligibility</td>
<td>Point Synergy</td>
</tr>
<tr>
<td>Line in A.P</td>
<td>42</td>
<td>42</td>
<td>108</td>
<td>148</td>
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<tr>
<td>Average of A.P</td>
<td>0.315231046</td>
<td>0.246862119</td>
<td>0.245383519</td>
<td>0.325573038</td>
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<tr>
<td>StdDev of A.P</td>
<td>0.097315936</td>
<td>0.067400531</td>
<td>0.070364415</td>
<td>0.091373974</td>
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<tr>
<td>Avg Population</td>
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<td>0.236649903</td>
<td>0.236679419</td>
<td>0.322595369</td>
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<tr>
<td>StdDev Population</td>
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<td>0.11633525</td>
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<td>0.140084687</td>
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<tr>
<td>Significance</td>
<td>154.6891076</td>
<td>183.9240362</td>
<td>151.5428752</td>
<td></td>
</tr>
</tbody>
</table>

Table 1: Statistical results of average neighbourhood polygon comparison with point synergy method

From table 2, we can see that the number of axial lines found inside the average polygon (A.P) and the average and standard deviation of those lines along with the values of the entire population (all lines) allowing the statistical significance that the values are selected at random to be determined. The significance factors (all greater than 3) reinforces the visual interpretation that the lines within the average bounds are not selected at random from the population but instead form a distinctive group.

Conclusions

In this paper, the author has demonstrated that it is possible to develop a point measure of local synergy and local intelligibility. Like Integration this measure is a purely descriptive measure of the configuration of the axial map that is in turn objectively derived from the construction of space. Like Integration this also appears to correlate with the real world phenomena such as a perception of the social function of space. It has been demonstrated by two methods that it is possible to compare the continuous regions of point synergy and point intelligibility with those of ‘named’ areas. This evidence appears to be consistent with the assertion that the regions of continuous point intelligibility are reflecting areas of potential named neighbourhoods. This work appears to contradict assertions to the effect that the configuration of space has no causative effect on the bounds of a neighbourhood and has no effect on the social neighbourhood alone.

References


