How big is your city, really?

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Abstract: Picturesque small scale environments may be much larger than they appear on maps if their size is gauged by their ability to house human activity. This, it is suggested, is because they are fractal and the size of a fractal is an ill defined quantity that depends on the unit of measurement. Since cities, especially old ones, are fractal, their size will depend on the scale at which they are used. Experiments at Manchester University exploring how size and scale are related, indicate that we may be able to make space appear as is from nothing by reducing our scale. These gains become very substantial when we go from the scale of cars to that of a pedestrian.

Introduction.

If you have ever wondered why when you take a new walk in the country it seems shorter than the return journey, or why your old school seems strangely small when you return as a grown-up then you may be interested to know that these intuitions are confirmed by results from experimental psychology which tell us that our perception of space and its size in square metres are poorly related, (see Crompton, 2005 (a) for references). These observations support the view that space is not a neutral medium in which objects stand but a social construction with which we interact. This concept of space is different from space as seen by surveying and is more like space as conceived by Lefbvre, who sees space as being transformed into lived experience by a social subjects of all sorts, young people, children, women, active people and so on, at work and at play. (Lefebvre, 1991).

A good example of space being changed by who you are and what you are doing may be found in Robert Graves's autobiography *Goodbye to all that.*

A Second Battalion officer, who revisited these Laventie trenches after the war ended, told me the other day of the ridiculously small area of No Man's Land compared with its seeming immensity on the long, painful journeys that he had made over it. "It was like the size of a hollow in one's tooth compared with how it feels to the tongue."

These observations are relevant to urban design because they raise the intriguing possibility that perceived size is something that can be controlled by a designer, that is, we might be able to manufacture space as if from nothing. Of course designer's folk wisdom already tells us ways of making places seem a little bigger or smaller than they ought to. We all know that white increases and black recedes and to avoid horizontal stripes if you want to look thin and so on, but I believe we can go much further than that. Are there types of space which can appear much bigger than others of the same area? A comparison of Hyde Park and the old city at Fez is rather telling. Fez is a labyrinth in which one can get lost for days, whereas the Park can be crossed in a matter of minutes. Similarly, in this same scale comparison, the darkened parts of the plan of Venice have the same area as Central Park, yet Venice seems much larger. How big is your city really? Measuring it in square metres may be very misleading.

Fractal and non-fractal cities

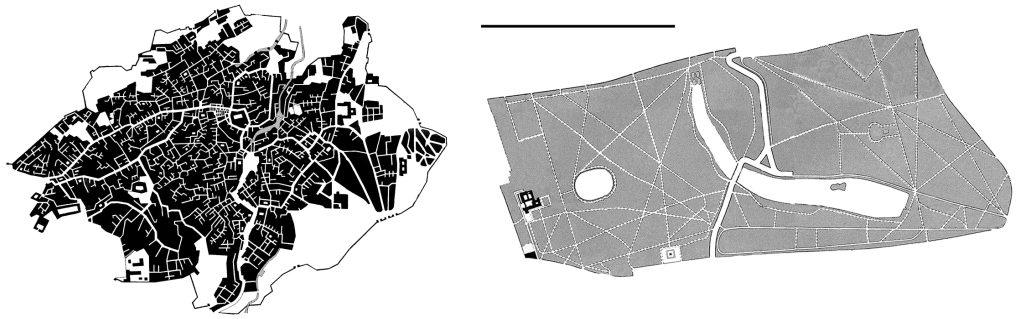

Figure 1. *Fez and Hyde Park to the same scale*.

Figure 2. *Venice and Central Park to the same scale*.

Both Fez and Venice are broken into a rich mixture of spaces with a range of sizes, some secret and some open quite unlike the regular division of a car park or stadium seating into equal parts. Fez may be crossed in many different ways without ever repeating your route and, although there are many routes across a large car park, such as a man methodically collecting litter might follow, to a pedestrian they are hardly worth distinguishing. Perceived size and complexity are plausibly related. For evidence from experimental psychology supporting this viewpoint see Montello, 1997. In what sort of places will the difference between measured and perceived space be most pronounced? I hypothesise that this will occur in fractal environments. That cities may be fractal has been known since Batty and Longley's book of 1994. Their studies dealt with the city at large scales, my belief is that everyday space in cities is fractal down to a small size, even down to the scale of a few centimetres. Both Venice and Fez are fractals, Fez in particular resembling a leaf skeleton in its street pattern. I propose that Venice is actually truly bigger than Central Park, it is not an illusion, and that it is inner fractal space that makes this so.

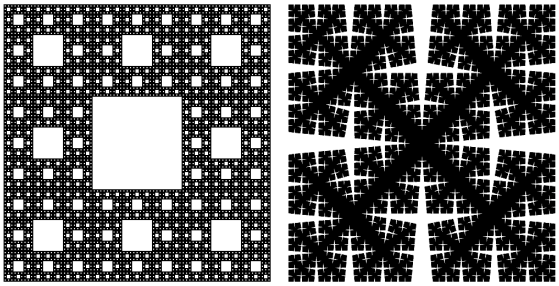

Figure 3. *Town and Country, (Sierpinski carpet and Cesaro Sweep).*

In a fractal a motif, is repeated over a range of sizes so that part of the fractal comes to resemble the whole from which it was extracted; which is to say that in a fractal things stay pretty much the same if you shrink. In fact the concept of size applies only weakly to fractals, in their most refined form they are scale free. Many objects in nature and art have this property, (see Voss, 1989 for examples). These two well known geometrically regular fractals (which I call *Town and Country)*, give an idea of the balance of large and small elements in a fractal.

It seems that we are predisposed to perceive and enjoy fractals. Cognitive scientists Yang and Purves have recently used a laser measure to show that campus and woodland environments are scaling as regards distances to objects in our field of view, (Yang and Purves, 2003). They used this discovery to explain five long standing unexplained optical illusions related to distance perception, such as the specific distance tendency, which are observed in reduced cue environments. It seems that we have evolved to expect our surroundings to be fractal and experience the world as slightly awry when they are not. Fractals are our default condition.

Fractals are associated with heaven. Both C.S. Lewis and J.R. Tolkein have written stories with happy endings containing descriptions of people entering heaven, and both these descriptions are clearly of fractal places with inner space, (see references for details). The opposite may also be true, not all environments are fractal and those that are not may be a little hellish. A place will be non-fractal if a particular scale predominates, as in a building with an array of windows all the same size, or perhaps because things at a particular scale are missing, as for example if small scale detail is omitted, or no if large scale parts are to be found. Airfields, car parks, many office blocks, and multilane roads are generally non-fractal.

Measuring fractal space

If an urban environment is fractal then its size will be a slippery concept and measurement of its size will depend strongly upon how the space is used. It was with this thought in mind that a series of experiments have, and are being, performed at Manchester University in the hope of putting this dislocation between sense and

measurement on a more scientific footing. Some of the experiments involved counting and classifying objects in domestic interiors, and by measuring the content of buildings over a range of scales it has been demonstrated that domestic interiors are to a degree fractal. Other tests involved counting places where certain activities can take place for different sized people. One experiment counted places to hide in a game of Hide and Seek, another investigated finding places to read a book, (Crompton 2001). These results of observing the reading experiment is shown below.

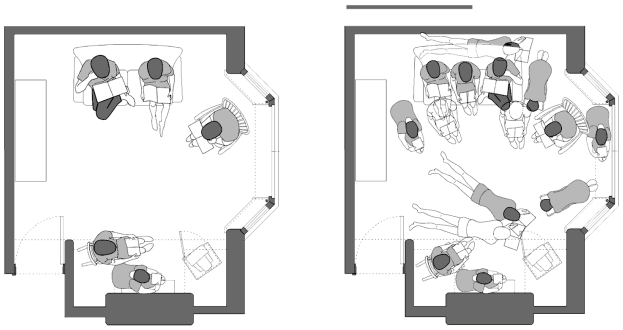

Figure 4. *Places to read a book used by adults and children*.

In both these tests children found more places to hide and read not only because they were smaller but because they were willing to use places that adults in their dignity would not notice. This is the reason that rooms seem bigger when you are a child. These experiments found a scaling relation existed between height and the number of places found for both activities. This suggests that domestic interiors are fractal as regards these activities. Houses contain inner space that can be found and used if you look for it like a child.

Is this extra inner space real? A recent experiment, (Crompton 2005 (a)) suggests that we are indeed conscious of it if an experiment investigating perception of walking distances in small scale complicated environments is to be believed. It compared estimates of a half kilometre walk in Portmeirion, an Italianate holiday village in North Wales, with estimates of the same distance along a busy road in Manchester. Portmeirion is a super-picturesque architectural folly where buildings are approximately seven eighths normal size. Parts of old buildings have been imported and recycled giving an appearance of picturesque sham antiquity. On high ground a romantic tower and domed building seem imposing from below but are actually rather small when approached. The roads are hardly wide enough for two cars to pass, indeed traffic is not allowed in the main part of the village. It was found that a walk in Portmeirion was felt to be between 2.0 and 2.5 times longer than a similar length journey in urban Manchester. These results, which are in the process of being published, still seem slightly amazing to me and are the subject of ongoing work which is repeating the experiment in other small scale

places. They do, so far as I can see, suggest that in small scale car free places distances are perceived as much bigger than in a city with traffic.

Figure 5. *Portmeirion, Italianate Village, Clough Williams Ellis, Architect, c.1930 - present.*

Space vanishes when you get bigger

The process by which space increases inwardly as you get smaller is just as interesting working in reverse; when you get bigger in a fractal environment space just seems to vanish. Now the easiest way to make yourself bigger is to put yourself in a car, how hard is it to play hide and seek in a car? The house used in the Manchester experiment provided fifteen hiding places for an adult in an area of 60 metres squared. What area would you suppose is needed to find fifteen hiding places out of doors if you are in an average car? The answer may be as much as 250,000 square metres. When the car is confined to public roads, hiding round corners in dead ends might be judged to correspond to a child hiding behind furniture. An estimate was made with a map based on a half kilometre block centred on the hide and seek house. In this area, which contained 406 houses, only eight hiding locations could be found, sufficient for perhaps twenty cars out of plain view. Even if the rules allowed hiding by parking in garages the total would only go up to about seventy five. For comparison; based on the indoor hide and seek experiment, allowing hiding in roads, gardens, and houses, I estimate perhaps 12,000 adults could conceal themselves out plain view in the same area. Putting yourself in a car hugely reduces the space available to you. Of course playing hide and seek in cars is a sport usually reserved for police and criminals and it generally requires a small town to make the game work, even then the game is easily won by using a helicopter. The fact is cars are hard to hide. It is a modern platitude to say that the world is shrinking, for people in cars it may indeed be true.

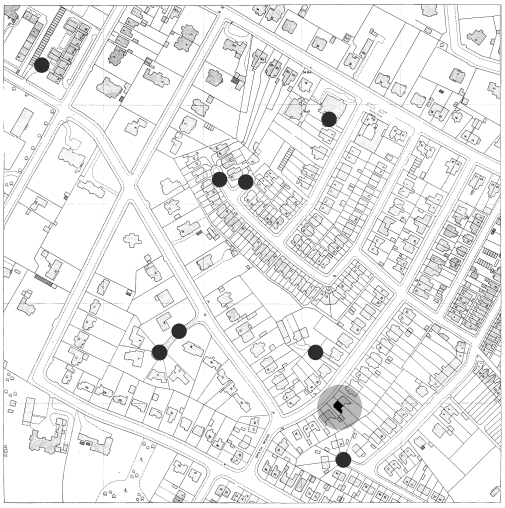

Figure 6. *Eight dead ends providing hiding places for about 20 cars, suburban Manchester.*

Car parking in a new light

This raises the question; to just what extent is the capacity of a city to absorb cars dependent on their size? To answer this Victoria Avenue, Manchester, a tree lined suburban road lined with semi-detached properties about a hundred years old, was surveyed in some detail. The survey went down to the level of gateposts, garden paths, dropped kerbs and so forth, along with interior plans of some of the thirty two houses. Using car and turning circle sizes taken from manufacturer's information, the numbers of cars the street could accommodate was found by drawing them on the plan, (according to simple rules, see Crompton 2005 (b)). Here we see the results of one the tests, (figure 8), it turns out that the street can accommodate forty four Rolls Royces, that is one for each house plus twelve for visitors. Larger than a Rolls is a removal van, at most twenty five could get in the road at once, and vehicles only slightly larger than that would be impossible to accommodate at all. This is the point at which space vanishes.

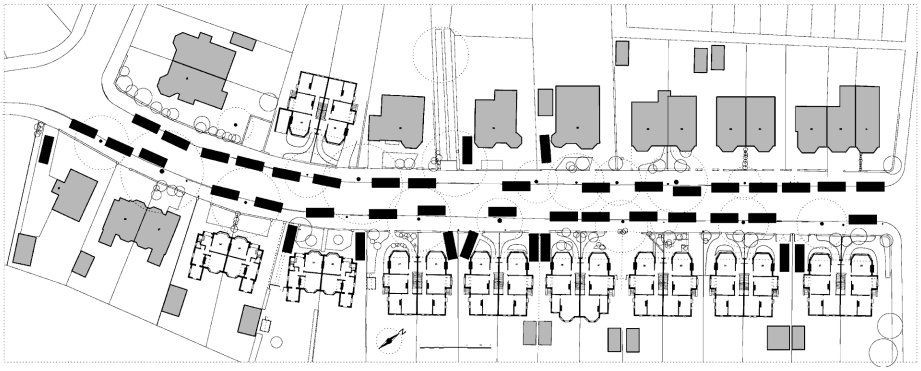

Figure 8. *Forty four Rolls Royce cars parked in Victoria Avenue.*

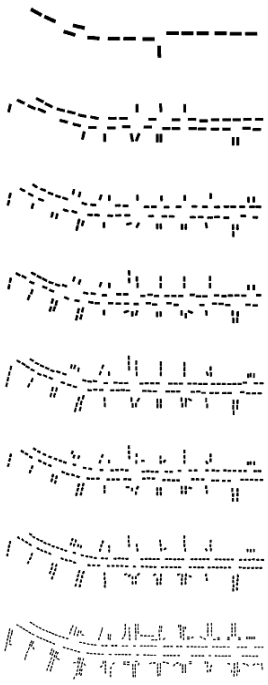

Figure 7. *Victoria Avenue filled with cars of different sizes; development of the parking fractal.*

When the cars got smaller the numbers that could fit in increased wonderfully. After the Rolls the tests looked at, in decreasing order of size, Volkswagen Golfs then Polos, old Austin Minis, Smart cars, BMW Isetta Bubble cars, and finally the Arrow buggy, an electric chariot something like a quad bike. The patterns they make as size goes down and numbers increase resembles an Aboriginal dot painting, it is a kind of fractal tree in which parts resemble the whole, after a change of scale. One might have expected that the number of cars which can be fitted would be proportional to their length but this turns out not to be the case. All the little complications in the Avenue mean that there are lots more spaces for small cars. The Avenue can accommodate 411 metres of Mini cars bumper-to-bumper, but only 333 metres of VW Golf cars.

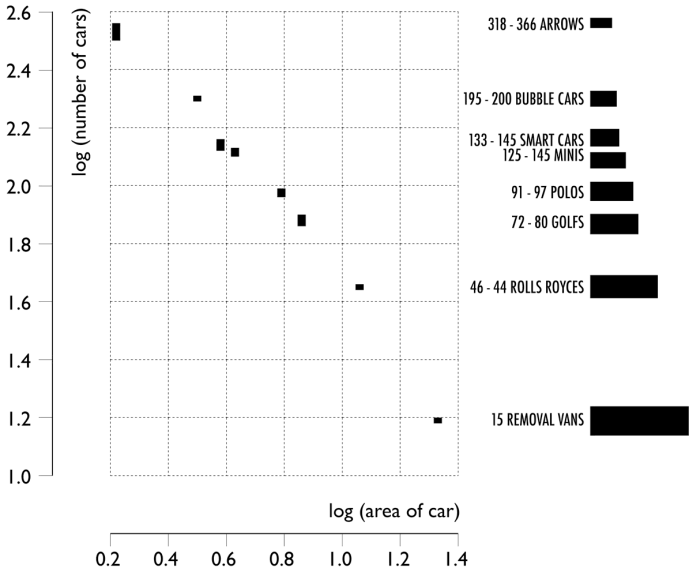

Figure 9. *Log-log graph showing number of vehicles versus their area.*

A log-log graph of numbers of cars versus length of car produces a straight line whose gradient is close to one, making this a 1/f relationship, a form often observed in nature, (see Voss 1989 for other examples, and see Salingaros and West 1999 for reasons for the ubiquity of this form). In suburban Victoria Avenue parking cars is fractal. The consequences of this relationship are as follows, as cars get smaller you can fit more in, obvious you might say, but there is an extra factor, you can fit in a lot more than you expect, there is, so to speak, a *fractal bonus*. If we reduce our size by a modest amount, from, let us say a VW Golf to a VW Polo we potentially fit 25% more cars in the street. If we go from a Golf to a Smart car we can at least double our capacity, and possibly do better than that if we bring into play new parking areas inaccessible to larger cars, for the experiment played safe by restricting its interest only to areas already used for parking. These sort of results will not hold in a car park where parking is confined to spaces that are the same for all cars. These places are non-fractal because a single scale, the standard car parking bay, predominates. By privileging this unit of space we create an unnatural and possibly oppressive environment ill suited for pedestrians and an environment which cannot take advantage of making cars smaller.

It ought to be pointed out that year on year cars are getting larger, each model is nearly always bigger than its predecessor. An example; the British Ford Anglia (1959 - 68) was 3.80 m long, today its descendent Ford's medium sized family car, the Ford Focus, is 4.37 m long. The expansion of cars over the past thirty years is roughly equivalent to the change from a present day VW Polo to a Golf, and this is over and above the inflation caused by people being able to afford bigger cars. The growth in traffic has perhaps masked this more subtle vanishing of communal space.

There is a strong parallel to this vanishing of space to be found in nature; small animals are common, big ones rare, a fractal environment is much much bigger for small rather than large creatures. It is the megafauna which goes extinct first, large animals run out of space before small ones do, so the beaver and the tiger are threatened but not the rat and the cat. Damuth (1981), has a graph showing a log-log straight line relationship between local population density and body mass of herbivores that is similar and analogous to the results of the hide and seek experiment. He used his results to show that the amount of energy used by a species is independent of body size, which is to say that no species has an advantage in consuming resources on account of its size. It is worth noting that no similar relationship exists for cars, the connection between metabolic rate and size breaks down because the same body shell is often sold with different engine sizes; further evidence that cars, unlike animals, are not designed to be in an economical balance with their environment and are to that extent unnatural. How ironic that cars are often named after the same large predatory animals whose problems of finding space they share.

How big is your city, really? Its size is a nebulous quantity that depends upon how you measure it. If it is fractal it can become much larger than you think if you shrink, even by a little amount. If you make yourself small the city expands to accept you, if you insist on being big it will squash you. Countries like Japan, where a modest standard of personal space is combined with small cars and an intricate environment may in fact be much larger than they appear on a map. Why do cities like Venice and Fez seem so big? Because they are fractal and are experienced at the scale of a pedestrian. Why do roads and car parks seem so crowded and oppressive? Because they are non-fractal euclidean places where movement is fettered by the law and other motorists. Spaciousness is connected with freedom and choice, something you do not have in traffic. If you look at space in terms of potential for activity then roads begin to appear as very constricted places indeed, as the regulated aggression of motorists testifies.

Conclusion

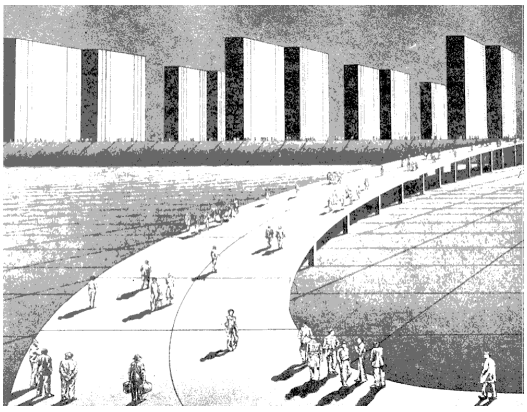

Figure 10. *City of the future.*

This drawing of a city of the future, like many other of its type, has no cars. I do not think that we necessarily have to go this far. Let me make this clear, I am not a car-hater, some of the happiest moments of my life have been spent in cars, in fact I come to save the car. The problem is one of the proper sharing of public space. When you drive a big car you are, in a fractal city, taking more space than you realise, you are being unwittingly selfish.


Figure 11. *Roman Parking, the problem.*

This is the problem, seen in Rome. According to the Manchester experiment Rome could accommodate two and a half times as many Minis as SUVs like this. This oversize car is taking not one but two and a half parking spaces.


Figure 12. *Roman Parking, the answer.*

And this is part of the answer, also in Rome, where micro cars are becoming common. All we need to do is get a little smaller and the fractal city will help us by magnifying out profits, if we choose to drive SUVs it will fight against us. The benefits of the extra space are over and above the obvious ecological and safety benefits of small vehicles.

Figure. 13.*Cobbles underlie macadam roads.*

A final thought; beneath many seamless macadam roads lies an older layer of stone laid out in units suited to the size of a man's hand. To make our cities more humane we ought to peel back this black fitted carpet and rediscover roads with a human scale. It is already there waiting for us if, like children, we only look for it .

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