
QUANTIFYING THE QUALITATIVE: an evaluation of urban ambience

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Keywords:

Urban ambience
Urban structural unit
Permeability
Legibility
Visual diversity

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Abstract

Delightful urban ambience is an important indicator of liveability; in turn liveability is a significant aspect of sustainability. But can this quality be quantified? To the extent that ambience reflects the (measurable) configuration of urban form; it is proposed that the comparative expression of certain ambient qualities can be evaluated between areas of differing morphology. Ambience may be conceptualised in terms of the properties of and relations among the distinct sets of elements, from building materials to city blocks, which comprise any given urban structural unit (USU), a construct prefaced on the morphological differentiability of urban form. This paper introduces the derivation of the USU and outlines the results of combining approaches derived from space syntax and fractal geometry to investigate three significant ambient properties – permeability, legibility and diversity – for three dissimilar USUs in Sydney, Australia. It concludes with a brief exposition of a method to test these results against user judgements, which are assumed to reflect the integration of perceptual cues from the environment.

Urban Ambience

A pragmatic definition of urban ambience is “the experienced physical and psychological qualities of the urban environment”. Ambience is based on the premise that comfort, satisfaction and delight results from the user's perception and interpretation of the physical state of an architectural or urban space. This physical state arises from the interaction of diverse factors including the properties of and relations among specific urban elements (building façades, vegetation, etc); natural phenomena such as microclimate and light; the urban soundscape; and human activities and interactions. Moreover, for a given physical state, the perception of an environment may change according to the user's intentions or activities. Urban ambience is thus the outcome of a complex composition of physical, physiological, psychological, sociological and cultural criteria (Dupagne and Hégron, 2002).

Urban ambience offers a more inclusive domain than the conventional focus on vision-centric urban design qualities to support discussion – and hopefully, elucidation – of the intangible properties of “wholeness” (Alexander et al., 1977), “responsiveness” (Bentley et al., 1985) and “imageability” (Lynch, 1960) which should characterise a socially and culturally sustainable city. However, the present paper concentrates on the widely acknowledged, predominantly visual properties of permeability (alternative ways through an environment), legibility (which makes a place comprehensible to an observer moving through it) and visual diversity, to test the utility of two specific approaches – space syntax and fractal analysis of street-level images – towards development of a composite methodology to inform more sustainable urban development.

The Urban Structural Unit

The multiplicity of methods for classifying urban form hinders urban analysis and by extension, urban design. Modification of the urban structural unit, originally devised to facilitate assessment of the metabolism of urban systems (Pauleit and Duhme, 1998), provides the foundation for a rigorous and replicable classification framework. USUs are broadly defined as areas of relative homogeneity with respect to the type, density and arrangement of urban form and open space which delineate distinct configurations of the built environment. Spatially positioned between the urban micro- and macro-scale, the USU facilitates comparison of results across and between cities, and has been used to support ecological urban planning, investigate hydrology, optimise waste management and model the environmental impacts of housing demand (reviewed in Osmond, 2006).

On the other hand, not all urban analysis takes place at this roughly “neighbourhood” scale. Moreover, methods for differentiating USUs have been largely project-specific, hence relatively subjective. A replicable method is necessary to disaggregate urban elements below this scale and to combine USUs to form higher-level entities, which in turn will inform the process of distinguishing one USU from another. Traditional (qualitative) urban morphology offers a solution, based on the description of built form in terms of the type, number and arrangement of its parts and their part-to-part relations, rather than explanation in terms of land use or stylistic/historical derivation (Kropf, 1993). Starting with the plot, Kropf proposes a methodical delineation of nine classes of built form from building materials to regional aggregations of “plan units”, a plan unit being basically identical with the USU.

However, extension of Kropf’s built form hierarchy to encompass the broader domain of urban form requires several additional criteria, in particular the hierarchical decomposition of (unbuilt) open space (Osmond, 2006). From this fundamentally morphological perspective, i.e. without including land use factors, an urban area may be effectively partitioned into “relatively homogeneous” USUs according to:

- The extent and arrangement of open space and its subdivision into paved and unpaved surfaces;
- The type, number, arrangement and part-to-part relations among blocks, street segments, intersections and squares;
- Vegetation structure and percentage cover; and
- Three-dimensional building outline.

Within each USU, specific sets and subsets of urban elements such as construction materials, buildings or gardens can be identified at the

appropriate level of resolution, and investigated via application of the appropriate tools.

Methods

In line with the above criteria, three USUs broadly characteristic of 1) inner Sydney suburbs; 2) outer suburbs; and 3) special-purpose campuses, were identified for evaluation (Table 1). Figure 1 depicts typical site views. Axial maps of the sites were prepared as layers on digital site plans using AutoCAD 2000, and space syntax analysis performed with Depthmap (Turner, 2004). Intelligibility measures were derived from connectivity vs. integration scattergrams for each site. As the UNSW campus contains distinct pedestrian-only and shared routes, separate analyses were conducted for the total site and the shared network.

Table 1:

Characteristics of the selected USUs

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Site, distance from CBD	Area (Ha)	Open space	Street network	Built form	Comments
1: Paddington (2km)	53	"Pocket" parks, small private and institutional gardens, street trees	Variable and intricate, including both "ringy" and "griddy" elements	Predominantly one- to three-storey terraced buildings on narrow lots	Dense, 19th Century inner suburb, small-scale retail and commercial development
2: Quakers Hill (38km)	190	Large front and rear yards, substantial open space reserves, and remnant woodland, few street trees	Feeder road/ cul-de-sac pattern	Low density, predominantly single-storey detached buildings	Rapidly growing, car-dependent 1990s outer suburb
3: University of New South Wales (6km)	38	Diversity of interconnected open spaces, substantial paved areas, significant number of mature trees	Extensive network of pedestrian and shared pathways, restricted vehicular access	Predominantly four- to eight storey buildings arranged in orthogonal pattern	Fifty year old campus of a large (26,000 students) university



Figure 1:

Typical images of (from left) Paddington, Quakers Hill and UNSW

Rectangular grids (Sites 1 and 3: 100x100m squares; Site 2: 200x200m) were superimposed on the site plans. Photographs taken from each accessible location within 5m of a grid intersection yielded samples of 29, 21 and 32 digital images respectively for the three sites. The photographs were taken at 30° from the longest line of sight with a lens viewing angle of 46°, approximating that of the human eye (Bovill, 1996), to simulate representative street-level vistas. Images were analysed with the shareware program Fractop (Weymouth, 2003), which incorporates image processing to reduce background noise, to derive their fractal dimensions (Db) via the box-counting method (Bovill, 1996).

Results

The values for mean connectivity, global and local (radius 3) integration, intelligibility and the mean fractal dimension of the street-level vista images for the sites are set out in Table 2. Figure 2 illustrates the associated axial maps (Rn and R3).

Site	Node count	Mean ax. length (m)	Mean conn.	Mean Rn	Mean R3	Intell.	No. of images	Mean Db and (range)
1	229	113.9	3.956	1.275	1.864	0.4537	29	1.746 (0.377)
2	113	224.5	2.531	0.966	1.262	0.4951	21	1.636 (0.364)
3 total	236	84.6	3.347	1.303	1.722	0.3803	34	1.704 (0.375)
3 shared	104	108.5	2.481	0.814	1.230	0.2936	N/A	N/A

Connectivity and global and local integration values are roughly similar for the Paddington and total UNSW systems, and significantly higher than for Quakers Hill and the UNSW shared route network. Mean axial length is markedly higher for Quakers Hill. Both Paddington and Quakers Hill show moderate intelligibility. However, UNSW, particularly the shared network, is relatively unintelligible, i.e. local spatial structure is not predictive of the global. Overall, the most highly integrated spaces (darker lines in Figure 2) coincide with observed pedestrian (Paddington; UNSW total) and vehicular (Quakers Hill; UNSW shared) movement, for example the University's central pedestrian mall.

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The Paddington data highlight differences between the older, more organic western sector and the grid-based late C19th development to the east, and indicate strong local integration in the central retail/services core of the "urban village". Both globally and locally, the "ringy" Quakers Hill network reflects the road hierarchy distributing commuter traffic to the relatively segregated residential culs-de-sac. A similar relation is evident between the underlying UNSW grid and the segregated pathways to individual buildings and open spaces. Of particular note is the University's disconnected shared route structure, designed to allow vehicle access for deliveries and perimeter parking without compromising the pedestrian setting.

Table 2:*Summary of site metrics***Figure 2:**

Axial maps of the three study sites: from top to bottom, Paddington, Quakers Hill, UNSW complete network and UNSW shared vehicle/pedestrian network; left hand side = Rn, right = R3. Note relative scale (black bar = 500m)

In relation to fractal dimension, higher Db values appear to be associated with visual enclosure, mature trees, building details and texture, and foreground elements such as parked cars, consistent with results reported by Cooper (2000). In this respect UNSW is closer to Paddington; the greater visual enclosure characteristic of the latter site may be matched by the greater height and bulk of the University's buildings in terms of effect on Db.

Discussion

How well do the quantitative metrics of space syntax and fractal geometry elucidate the properties of permeability, legibility and visual diversity, identified as contributing to positive ambience? An integrated system is one in which any space is topologically close to any other space, implying good access (Lynch, 1981), and high connectivity implies alternative ways (Bentley et al., 1985) through an environment. Observation of pedestrian and motorist behaviour across the three sites supports a comparative permeability ranking of Paddington > UNSW (total) > Quakers Hill > UNSW (shared), consistent with quantitative integration and connectivity data.

The quantification of legibility is more complex. Despite a superficial similarity, it is not synonymous with intelligibility, which assumes that cognition of small-scale spaces both precedes and facilitates cognition of large-scale spaces (Jiang et al., 2000). Penn (2003) proposes that "cognitive space" may be topological rather than metric. Nevertheless, topology is only one aspect of legibility as commonly understood as an urban design quality. If a route is essentially a sequence of vistas and transition points where new environmental information is gained (Haq, 2003), what kind and amount of information enables the user to perceive one urban environment as legible, and another not? This study suggests that metric scale has a role in explaining legibility. Pedestrianised Paddington and car-oriented Quakers Hill feature similar intelligibility values, but mean axial length of the latter system is nearly twice that of the former. The rate at which visual information is presented is a function of distance travelled per unit time, so the motorist's perception of intelligibility is clearly different to the pedestrian's. Hence axial length may act as an intervening variable between intelligibility and the perceived legibility of a street network from these divergent user perspectives. If legibility is predicated on both content and accessibility of information, intelligibility represents the accessibility (or configurational) dimension of legibility.

Cooper (2000) found the fractal dimension of photographs of street-level vistas to be a reliable indicator of relative visual diversity, based on the correlation between Db and subjective evaluations, and the present results confirm that fractal analysis can discriminate between visually distinct environments. A more visually diverse environment is also considered inherently more legible, so fractal analysis of street-level views may also shed light on the informational dimension of legibility.

Conclusions and Further Research – The Brunswick Lens Model

This research confirms the utility of the urban structural unit as a practical framework for urban analysis. It suggests that space syntax and fractal geometry can help quantify permeability, visual diversity, and tentatively, legibility, for which an as yet undetermined synthesis of intelligibility, axial length and fractal dimension may afford a functional metric. However, development of reliable indices requires validation against observed behaviour and crucially, against subjective user judgements. There is significant evidence, for example from wayfinding research (Passini, 1996), that the more complex an

environment, the more dependent the user on the integration of multiple, individually incomplete bits of information. The Brunswik lens model presents a way to interpret this complexity. Egon Brunswik was a contemporary of James Gibson. Both focused on organism-environment relations, but where Gibson held that people directly perceive and act on meaningful environmental information, Brunswik maintained that perception relies on integration of a series of cues, each of which provides partial information (Hammond and Stewart, 2001).

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Current lens model research largely concentrates on the field of judgement and decision-making (Cooksey, 1996), which commonly involves situations characterised by causal ambiguity, underlining the relevance of probabilistic cues. Pertinent to the present study is Gifford's (2000) lens model comparison of architects' and laypersons' perceptions of modern architecture. Figure 3 outlines a potential avenue for further research, drawing on Gifford's two-stage method, to assess the relative contribution of physical cues to users' judgements of urban ambience.

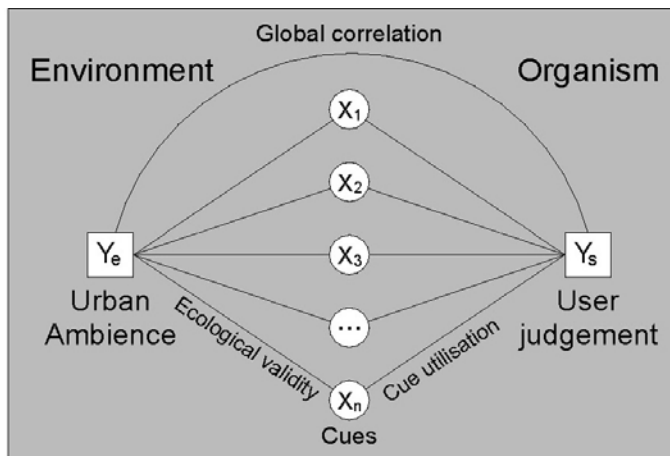
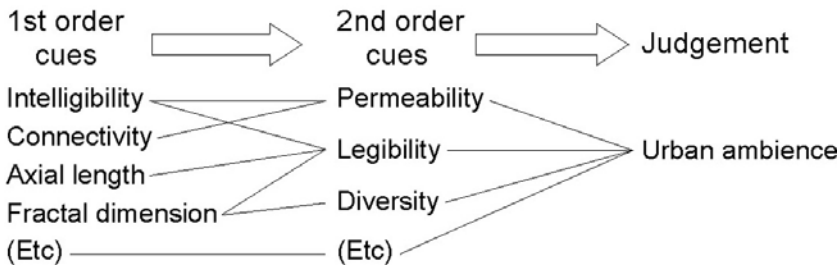


Figure 3:

The Brunswik lens model represents the relation between environmental criterion Y_e and user judgement Y_s as expressed through a set of cues $\{x_1 \dots x_n\}$. The relative contribution of each cue to the user's global judgement is assessed through multiple regression. In the current context, "first order" cues manifest in terms of "second order" properties, which translate into an overall judgement of ambience



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