

## #98

### RELATING URBAN MORPHOLOGIES TO MOVEMENT POTENTIALS OVER TIME

A diachronic study with Space Syntax of Liverpool, UK

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#### ABSTRACT

In this paper we describe our observations of Liverpool's (UK) syntactical patterning relating to its urban network growth from 1850s to the present day. Liverpool's rapid growth and transformation provides a compelling case study of network configurations as they relate to movement potentials over time. We argue that syntactical analysis of movement potentials provides a tool for evidencing urban historical socio-spatial patterning. Urban patterning might be shaped variously by historical factors such as socio-economic inequalities, labour divisions, ethnicities or religious denominations. We have attempted to demonstrate how movement potentials have persisted normatively along structural path-dependencies that underpin these patterns.

We based our study on samples of three prominent centralities of Princes Avenue, Scotland Road and Canning Place, across four periods: 1850s, 1890s, 1950s and contemporary. We prepared Depthmap data samples using an arrayed visualization format, which allowed us to make comparative observations of movement potentials as they converge and intersect across various urban scales. This has allowed us to generate 'internal' perspectives on configurations over time, to suggest some possible effects of city-scale morphologies on local spatial dynamics.

#### KEYWORDS

Urban morphology, movement potential, Liverpool, Space Syntax, urban history

#### 1. INTRODUCTION

Britain's rapid industrialization was driven by mass manufacturing across Lancashire coupled to Atlantic trade via the port of Liverpool (Hobsbawm, 1962, p.49-50). By the mid 19th Century, the city's extensive wharf complex carried the world's highest volume of cargo (Aughton, 2008, p.217). Much of Liverpool's economic activity was focused along this complex (only a minor manufacturing area was centred around the Ropewalks area). The city's high-density urban networks radiated outwards from the riverside, wherein some localized centralities supported trade and consumption. Massive inward migration from across the British Isles also led to highly segregated communities based on religion, nationality and work. Irish Catholics made up largely unskilled labour sub-groups around Scotland Road. Welsh Presbyterians made up semi-skilled labour groups around Princes Avenue. English and Scottish Protestants made up skilled labour and clerical groups also around Princes Avenue and in suburban areas (Pooley, 1977; Lawton, 1979). See Figure 1 for a map showing the main locations referred to in this paper.

By 1911, when construction of the landmark Royal Liver Building was completed, the port city had reached its peak of growth and innovation, followed by a decades-long process of general decline. The Depression of the 1930s led to one of third of working-age men being out of work (Aughton, 2008, p.244), and wartime bombardment and displacement led to intensive damage to the city's fabric. In the postwar years, road building, slum clearances and mass rehousing led to a precipitous decline in population within a severely post-industrial landscape (Cf. Sykes et al, 2013). High unemployment and social exclusions led to the major Toxteth Riots of 1981, which furthered the distress to Liverpool's urban fabric. In spite of recent urban developments, Liverpool remains one of the most deprived cities in the UK measured by IMD, featuring extensive zones presenting high unemployment, high rates of chronic illness, low rates of educational attainment, and low longevity (LCC, 2015).



Figure 1 - Annotated map of Liverpool's street network in the 1890s, showing areas sampled and key locations described in the study

The urban history of Liverpool provides a compelling case study in rapid industrial transformation and accelerated decline. Tracing the distinctively 'urban' evolution of a city poses a range of epistemological dilemmas, which we have attempted to resolve to some extent in this paper. Firstly, do we deal with the city as an autonomous or as a complimentary entity within its wider spatio-temporal context (Jansen, 1996)? Secondly, how do we reflect the general 'problem' of urban space as, at once, the locus of everyday living and the site of normative (cultural and ideological) reproduction (Rodger and Sweet, 2008; Lefebvre, 1991, p.50; Hillier and Hanson, 1984, p.22)? Thirdly, how do we accommodate the paradox of the city as both a compressor of space-time, in terms of rates of flows and exchanges, and as an instrument for socio-spatial distancing, in terms of social differentiations expressed in spatial patterning (Dennis, 2008; Massey, 1994, p. 147), and relational complexity (Hillier, 2007, p. 67-68; O'Brien and Psarra, 2015)?

Space Syntax offers a method to address dualities in urban formation through its 'configurative' model of morphological generation, whereby generic spatial patterning relates dynamically to characteristic social practices (Hillier and Vaughan, 2007). This approach has been successfully applied to a range of 'industrial age' urban histories (for example, Psarra et al, 2013; Griffiths,

2009, 2017; Al-Sayed et al, 2009; Pinho and Oliveira, 2009; Vaughan, 2007; Vaughan and Penn, 2006; Medeiros et al, 2003). However, Hillier and Hanson's configurative theory, from which these analyses have extended, has been critiqued for its epistemological perspective of an 'external observer' of urban space (Griffiths, 2011). We argue that the configurative perspective should be that of the 'internal observer', whose situated space-time coordinates determine a localized (relativistic) modality for spatial description. The 'internal perspective' is pertinent to urban historical analysis when we conceive of how flow rates through urban networks in the past related to the capacities of their dominant mobilities (Urry, 2004). For example, the movement-scale paradigm of a predominantly pedestrian milieu offers affordances for spatial description that are qualitatively differentiated from those of an automotive milieu. Moreover, these local spatio-temporalities set in place basic components for the urban system's spatial evolution. As such, we cannot describe an urban history without considering the 'clocks' of its landscape (Ingold, 1993).

Urban historians are presented with a challenge in evidencing relativistic spatio-temporalities (Pooley, 2000). Pooley (2016) has reviewed, for example, a diverse set of historical materials relating to transportation-in-use within British conurbations. From the evidence available, it appears that most urban inhabitants from the mid 19th Century walked or took horse-drawn and, later, electric omnibuses. Suburban inhabitants in the early 20th Century depended on electrical omnibuses and, later, on personally driven automotive cars (that from the later 20th Century also introduced social inequalities of inclusion and accessibility).

Another approach to this challenge might be sourced from the Space Syntax notion of natural movement potential (Hillier and Iida, 2005), which encapsulates a method to recover probabilistic urban movements from the 'internal observer' perspective. Natural movement potentials (represented through Space Syntax measurements of Choice and Integration) may approximate the inter-relationships of these movement scales and network morphologies, as well as interactions between scales such as those between local through-movement and global to-movements – while recognizing that labels such as 'local' and 'global' are normative and negotiable over time. Space Syntax can provide the urban historian with 'potential' evidence that engages in new ways with traditional data sources; for example, in relating street networks bearing high Integration values to census data reflecting demographic segregation in those areas – as was typical of 19th-century Liverpool (Pooley, 1977; Lawton, 1979). In this paper, we mainly explore Space Syntax as a theory and a method for breathing new life into such sources, offering richer interpretative possibilities than conventional GIS visualization techniques (Griffiths, 2012, 2013; Vaughan and Penn, 2006).

## 2. DATASETS AND METHODS

In investigating Liverpool's historical urban network we sampled three major centralities converging around Princes Avenue in Toxteth to the city's south, Scotland Road in Everton to the north, and Canning Place in the city centre. The urban networks were modelled by tracing Ordnance Survey Ancient Roam tiles using QGIS. The tracings were exported to Depthmap for recalculation with angular segment normalized Choice and Integration measures (NACH and NAIN), based on metric radii of 200m, 400m, 800m, 2000m, 5000m and 'global n' scale respectively. We sampled from four historical periods: the 1850s marking the height of Liverpool's first wave of expansion; 1890s as the period approaching the city's economic zenith; the 1950s marking the city's network maximum; and the contemporary network subsequent to major remodeling and developments. In addition, we generated a Depthmap model (NACH and NAIN, R100, R250, R400, Rn) to reflect urban redevelopments to the city centre in the 1970s.

This diachronic sampling constitutes one section of a broader project at University College London, 'Visualizing Community Inequalities' (supported by the Leverhulme Trust). The project seeks to describe contemporary community formations in relation to persistently 'imageable' urban forms, such as boundaries, interfaces and thresholds (Conroy-Dalton and Bafna, 2003; Lynch, 1971). To achieve this kind of observation, we generated Depthmap model arrays using an R programming environment (RStudio), to make comparative observations 'within the

eyespan' (Tufte, 2006). This comparative method is reflected in our citing throughout text of the radial scales from which we made our observations (e.g. 'NAIN 400', 'NACH 5000' and so on). We provide an overview of the diachronic samples in Figures 2 and 3.

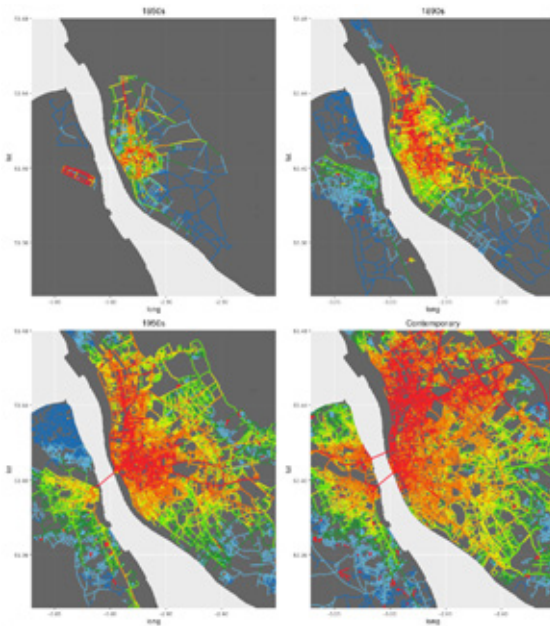


Figure 2 - An array of Depthmap models of Liverpool, UK, representing the syntactical evolution of urban regional Integration over four historical periods (NAIN Rn)

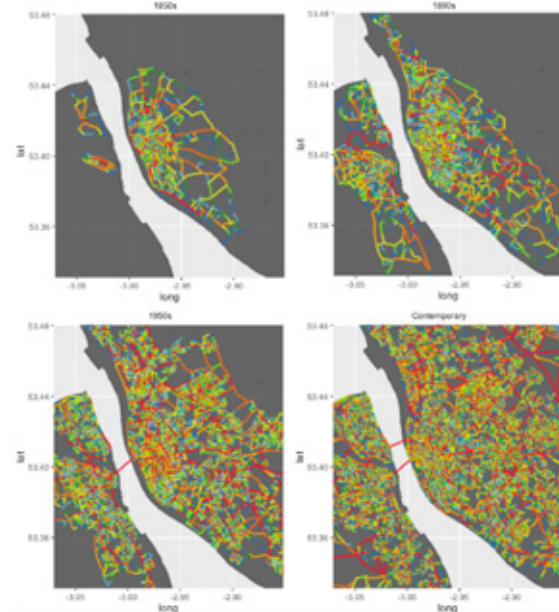


Figure 3 - An array of Depthmap models of Liverpool, UK, representing the syntactical evolution of urban regional Choice over four historical periods (NACH Rn)

## 2.1 PRINCES AVENUE, SOUTH LIVERPOOL

Princes Avenue is a boulevard complex, built in the 1840s along an east-west axis over ancient parkland and gardens. The avenue connected the new metropolitan Princes Park to high-status residential areas. It was constructed as a dual carriageway that continues to play a major role in the urban formation of Liverpool's Toxteth area (Figure 4). By the 1850s, several local plots had been developed with densified terraced housing, forming distinctive grid patterns. These sections presented overall low Choice, compared with that of the burgeoning city centre, and were separated functionally from the wider network by the foreground structures of Upper Parliament Street (NAIN R5000).

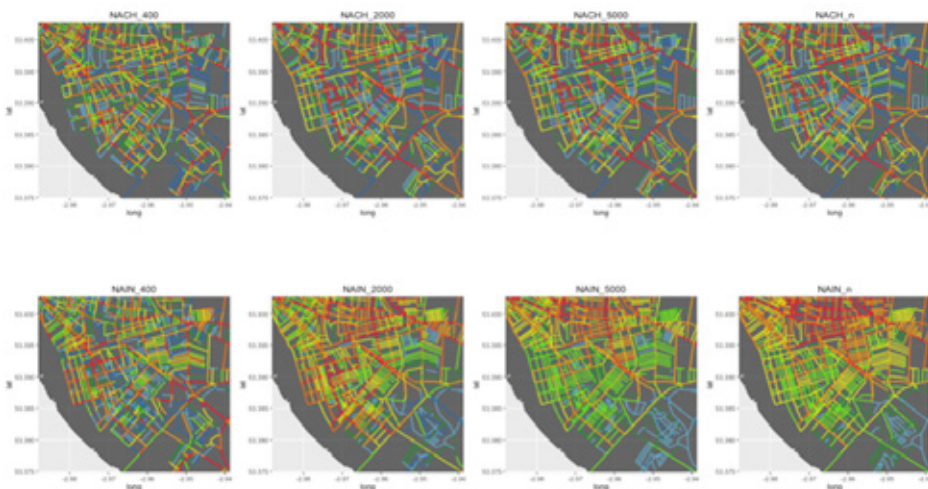


Figure 4 - An array of Depthmap models of Liverpool's Princes Avenue area (1890s map)



The land surrounding Princes Avenue had been urbanised with high-density terraced-housing street sections (and given characteristic nicknames; see Figure 1, points 10-13). Movement potentials within the local street sections were based on generally low-movement structures of short, straight street segments (NACH 400, 2000). These were connected at the perpendicular to moderate-movement segments, together bounded by street segments presenting high Choice at wider scales (NACH R400, R2000 and R5000).

Separate to the high-density grids, the interstitial 'Granby Triangle' was the location of ostensibly higher-status housing, along with a cluster of landmark Protestant, Orthodox and Jewish places of worship. Princes Avenue afforded these families improved accessibility to the city centre, to omnibus services, public parks, mercantile and cultural quarters (NAIN R800 and R2000). In contrast, movements of the Welsh Streets and Holy Land seem to remain orientated to the riverside industries (NACH and NAIN, R400 and R2000).

By the 1950s Liverpool had undergone a second-wave expansion based around low-density suburban and peripheral developments, inter-connected by a radial complex that included the Queens Drive ring road (opened around 1920) and the Mersey 'Queensway' Tunnel (opened 1934). Intensive wartime bombardment had led to several major disruptions to the urban fabric; nevertheless the Victorian urban network remained largely intact. The expansion of the network overall appears to have increased high Choice values along Princes Avenue, as well as among its adjacent street-section areas (NACH R800, R2000, R5000). The array of rectilinear segments now inter-connected the street sub-networks (NACH R200), with movement flowing along Princes Avenue and into to the urban-scale centrality along Upper Parliament Street (NACH R5000). Together these provided consolidated accessibility from all street sub-networks to the city centre (NAIN R400, R800, R2000, R5000), although accessibility from Princes Avenue to the newly expanded network was apparently more limited (NAIN R5000, Rn).

The 1950s also mark a pivotal moment in Liverpool's economic and social decline. Granby's prosperity lasted from the city's economic zenith of the 1900s until the early 1960s. After this period Granby experienced a rise in crime, which led to the widespread installation of bollard arrays to prevent kerb-crawling (SNAP, 1972), which diminished Choice and Integration among the street network (NAIN and NACH R800, R2000).

This pattern of functional severance may have intensified a tendency towards spatial and demographic segregation, reflected in a concentration of non-white British populations within the Granby Triangle (HMSO, 1981). Relating to this, in 1981 a major riot broke out on Selbourne Street (an internally integrated segment within the Granby Triangle; NAIN R800), which led to the destruction or demolition of 70 buildings in the near vicinity. In the aftermath of these events, Liverpool City Council undertook the Urban Regeneration Strategy, to develop additional low-density housing close to the city centre.

Today, Princes Avenue presents high Integration from Liverpool's southern periphery to urban centre (NAIN n). Strikingly, the southern carriageway of Princes Avenue (conveying traffic into the city centre), now presents low Choice (NACH R2000), compared to the generally high value of the 1950s. The avenue's segment lying perpendicular to the Welsh Streets appears to be a weak attractor for the local network (NAIN R400), which is perhaps a dynamic feedback from extremely high rates of vacancy along these streets. Also striking in the vicinity are the persistently high Choice and Integration values along the north-south axis of Lodge Lane, representing an emergent local and city-scale centrality (NACH and NAIN, R400 and R5000).

## 2.2 SCOTLAND ROAD, NORTH LIVERPOOL

Scotland Road is a major conduit situated on a natural elevation along a north-south axis, connecting Liverpool's urban centre to northern regional areas. It was developed as a highway in 1803, adjoined by an array of high-density terraced and court-yarded streets. Scotland Road (Figure 5) ran between distinctive areas of Vauxhall and Everton, which were associated with Protestant and Catholic migrants from within the British Isles.

Everton in the mid 19<sup>th</sup> Century featured a localised 'ladder' pattern of short streets that afforded overall good accessibility to the wider urban network (NAIN R<sub>400</sub>, R<sub>800</sub>, R<sub>2000</sub>). These street sections were inter-connected via functional 'bridges' that traversed local- and city-scale urban sub-networks (NACH and NAIN, R<sub>400</sub> and R<sub>2000</sub>), including economic centres of the mercantile quarter and riverside complexes.

The location of the North Hay Market, widely known as 'Paddy's Market', formed a major centrality for surrounding streets and the wider urban network (NAIN R<sub>400</sub>, R<sub>2000</sub>, R<sub>5000</sub>, R<sub>n</sub>), (Figure 6). Highly significant in this dynamic was the perpendicular junction of Juvenal Street and St Anne Street, from where the market could be entered, forming a pivot of convergence for Liverpool's network globally (NAIN R<sub>n</sub> and NACH R<sub>n</sub>). The affordances for economic and social mobility brought about by these encounters are perhaps reflected in the innovative public housing established at close-by Summer Seat and Eldon Grove (1911-12).

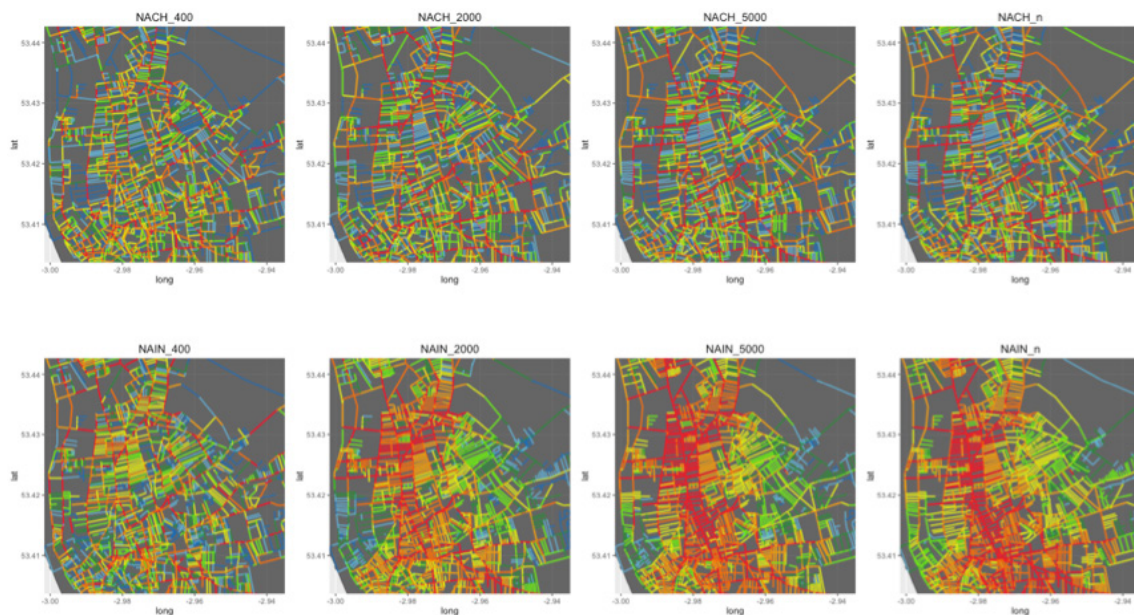


Figure 5 - An array of Depthmap models of Liverpool's Scotland Road area (1890s map)

The contemporary map represents intensive redevelopment of the 1960s, including widespread demolition of the 'ladder' streets, and construction of radial roads and the Mersey 'Kingsway' Tunnel complex (opened 1971). This radial expansion integrated the urban peripheries but formed prominent boundaries between the northern districts and wider network (NAIN R<sub>5000</sub>, R<sub>n</sub>), and localized lacunae in the urban fabric. The location of Juvenal Street is now, sadly, a barren pedestrian bridge over the subterranean tunnel approach, bearing only moderate prominence as an attractor and conduit at all scales (NAIN AND NACH, R<sub>400</sub>, R<sub>2000</sub>, R<sub>5000</sub> and R<sub>n</sub>).

The sites of many of the 'ladder' streets have been redeveloped with low-density semi-enclosed complexes across north Liverpool. Together these form a loose cluster with overall low local Integration (NAIN R<sub>400</sub> and R<sub>2000</sub>), also demarcating a zone of among the highest multiple deprivations in the UK (ONS, 2015). The low-density housing complexes have led to poor connectivity among the north-south axes of Scotland Road and Great Homer Street, with only St Anne Street affording direct access between the roads (NAIN R<sub>400</sub> and R<sub>2000</sub>, NACH R<sub>2000</sub>). The overall poor connectivity between the north-south axes is perhaps suggestive of areas with weak local inter-connectivity and subject to movement from across the wider urban network.

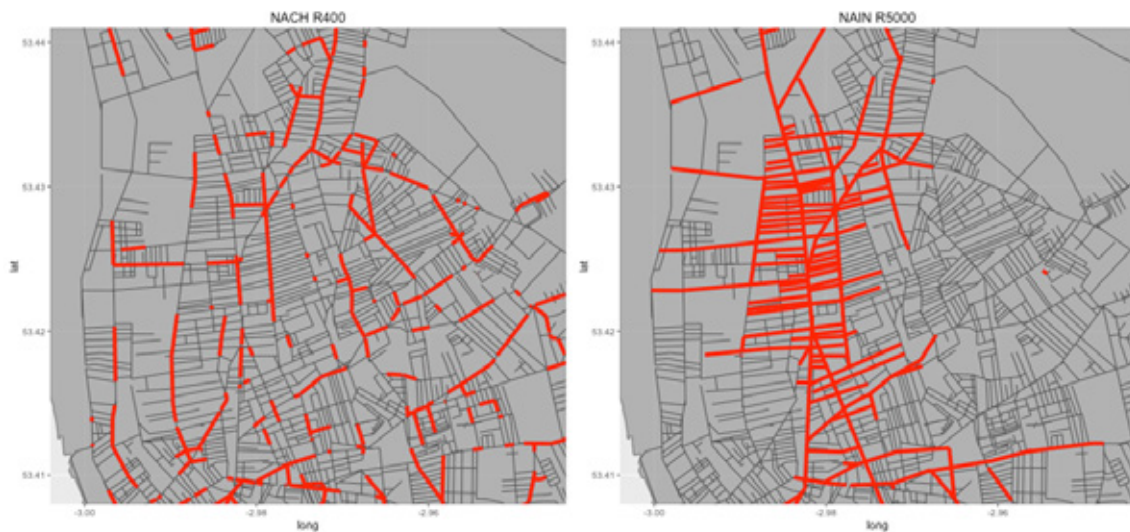


Figure 6 - Depthmap array showing top quintile value ranges for NACH 400 and NAIN 5000, highlighting the ways in which local high Choice around Paddy's Market may have coincided with a city-wide attractor.

### 2.3. CANNING PLACE, CENTRAL LIVERPOOL

Canning Place is the site of among Liverpool's earliest urban spatial structures and converges a historically persistent centrality at multiple network scales (Figure 7). From the 1850s, Canning Place formed a significant attractor within the city-wide network (NAIN R2000). At the local scale, Canning Place inter-connected the mercantile quarter around Dale Street, the cultural quarter around St George's Hall (NAIN R400), and functionally integrated this sub-network with the Scotland Road axis via Whitechapel (NAIN R2000), and to regional routes (NAIN Rn).

The southern edge of Canning Place formed part of a boundary around the 'maritime quarter' sub-network, bisected diagonally by Paradise Street that traversed the 'mercantile' and 'cultural' quarters' sub-networks (NAIN R2000 and R5000). As such, the place's southern edge formed a powerful attractor and conduit for movement at all scales, converging along the city's foreground network (NAIN and NACH, R400, R2000 and R5000). Benefitting from this major, multi-dimensional centrality, Canning Place was the location for Liverpool's impressive Customs House.



Figure 7 - An array of Depthmap models of Liverpool's Canning Place area (1890s map)



By the 1950s, after intensive bombardment, the Customs House had been demolished along with most of the surrounding buildings. This led to a general decrease in movement potentials around the site (NACH and NAIN, R2000). However, the southern edge of Canning Place, which formed an axis with Hanover Street, remained functionally resilient to the damage in the surrounding network. It continued to serve as a conduit from Strand Street to the newly established radial routes into the city's expanded suburbs (NACH R2000, R5000, Rn).

Canning Place's 1970s redevelopment involved a complex of municipal buildings and Strand Street's redevelopment as a multiple-lane highway (Figure 8). Significant to the sub-network's connectivity with the wider network, the major axis of Upper Frederick Street that connected Canning Place with residential areas to the city's south (ultimately including the Princes Avenue area), had been devastated by wartime bombardment, yet was partially restored in the 1970s redevelopment. This served to increase Choice within the Canning Place network (NACH R400). However, a major housing development initiated by the City Council in 1984 severed the junction of Upper Frederick Street and Paradise Street.

Cable Street and Thomas Street had provided, until the wartime period, city-wide attractors and conduits that linked South John Street and Paradise Street (NAIN and NACH R2000). Notably, these structures formed part of a prewar sub-network (observable from the 1890s, NAIN R400). Their 1970s successor was a pedestrian pathway of sorts, passing through a car park and bus terminal. In spite of this architectural disruption, this pathway maintained its movement potential as a local attractor (NAIN R400). This functional persistence possibly speaks to a spatial logic for movement that has formed from the foreground structure of the Great George Street/Berry Street axis (forming the city-centre's western edge), and its functional connectivity, via Seel Street/College Lane, with the natural flow of Paradise Street.

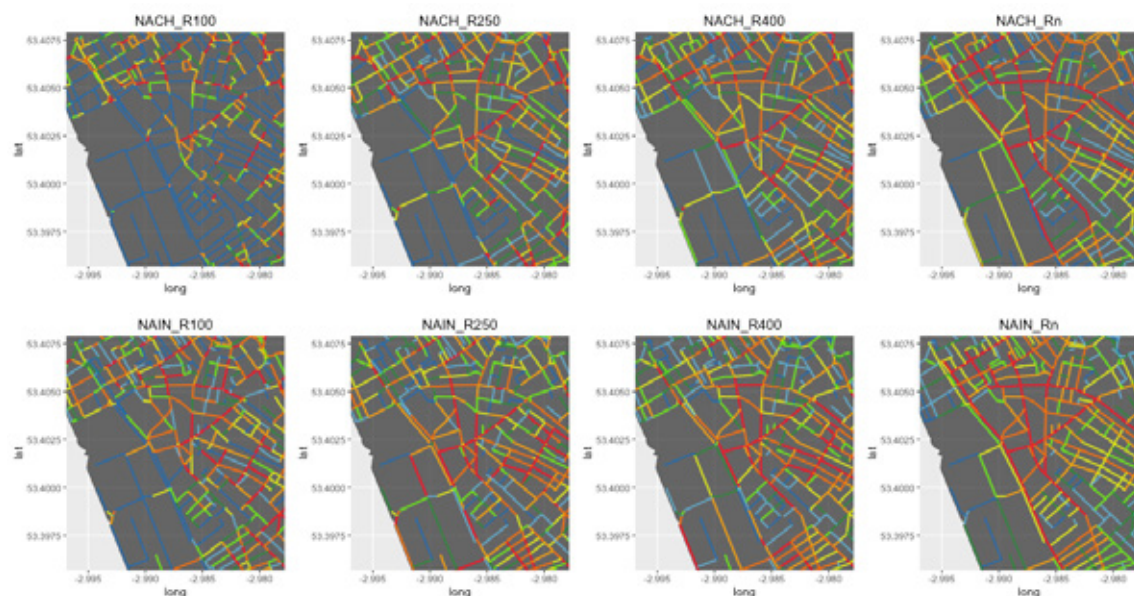


Figure 8 - An array of Depthmap models of Liverpool's Canning Place area (1970s map; detailed)

The area's redevelopment of 2004-2008 involved demolition of the 1970s architecture, and pedestrianization of local thoroughfares. The development restored the earlier prominence within the network of Canning Place's northern edge, now called Thomas Steers Way (NACH and NAIN, Rn), to provide pedestrian access to a new retail area. What is today called Canning Place is formed from its erstwhile southern edge, comprising a walkway and roadway for the main bus terminal. The roadway has maintained its historical prominence at local and city-wide scales (NAIN R400 and R2000). However, its walkway that was once the location of the Customs House forecourt has become functionally disconnected from movements among Liverpool's foreground network and southern neighbourhoods (NAIN R400 and R2000).



### 3. DISCUSSION

Our aim in using syntactic descriptions for making detailed diachronic observations of Liverpool's urban development was to demonstrate how a 'normative' method for historical and spatial comparisons could reveal path-dependencies with the capability of underpinning urban images, including boundaries, thresholds, interfaces, gateways and bridges through which community identities are negotiated and controlled.

The Depthmap model arrays provided compelling observations of Princes Avenue's function as a boundary and threshold between the sub-networks to which it was inter-connected. On the basis of this research one can propose how populations occupying Granby, the Dickens Streets and Welsh Streets in the mid 19<sup>th</sup> Century appeared to experience different orientations with respect to the wider network. Princes Avenue provided the major conduit for access to the metropolitan network, but with low inter-connectivity among the local networks. This suggests that Granby, the Dickens Streets and Welsh Streets were functionally separated and, we anticipate, socially segregated.

We discovered several examples of systemically confluent conduits and attractors that have, we argue, played various parts in community life at the different historical intervals we sampled. For example, Paddy's Market in the mid 19<sup>th</sup> Century attracted localized movements, as we might expect from such a significant place in the urban landscape. The syntactical model also revealed how this local sub-network converged with through-movement structures at the wider city scale, possibly revealing its function as an interface between working-class communities to the north of the city and various populations from across the city. We also observed how the radial road developments of the late 20<sup>th</sup> Century formed structural boundaries between these local sub-networks and the wider network, also reflected in their experiences of slum clearance, mass relocation and de-densification.

A historical threshold pattern is also detectable along Scotland Road that, in the mid-to-late 19<sup>th</sup> Century and into the mid 20<sup>th</sup> Century, provided a conduit into the city, but functioned as the dividing line between different local sub-networks. This major road provided accessibility to sub-networks proximal to riverside industries, meaning the various populations occupying distinctive (and segregated) areas encountered each other along its segments. We observed how functional 'bridges' around Scotland Road traversed residential and industrial areas. Their street corners and local pubs were likely to have been significant gateways for economic and social brokering, not least given the casual availability of work. These spatially 'trivial' yet socially important street segments warrant further analysis.

We also discovered the resilience in movement potential of segments relating to the Canning Place sub-network. The northern and southern edges of the place have persisted as a significant interfaces between various sub-networks including, in the late 19<sup>th</sup> Century, those of the mercantile and cultural quarters and those of the socially mobile Princes Avenue quarters (though less so with regard to the lower working-class areas to the city's north). We included an overview of structural interventions of the 1970s, which weakened the functionality of Canning Place as a conduit and attractor within the local and wider networks; its northern edge in particular became demoted as a city-wide centrality. We also observed how redevelopment in the 2000s restored the northern edge's functionality within the local network, and promoted its southern edge within the wider network.

### 4. CONCLUSION

This study has offered a visualization method for making systematical observations of the historical growth of an urban street network that facilitates new forms of engagement with other sources of evidence and approaches to the study of urban history. Furthermore, we believe that it has produced evidence for the existence of normative 'images' of urban community formations in the historical street network. Further work using, for example, contemporary demographic data, journalistic accounts and individual testimonies, as well as greater statistical validation, is required to establish the credibility of this hypothesis.

## REFERENCES

- Al-Sayed, K. and Turner, A. and Hanna, S. (2009), 'Cities as emergent models: the morphological logic of Manhattan and Barcelona'. In: Koch, D., Marcus, L. and Steen J. *Proceedings of the Seventh International Space Syntax Symposium*, Stockholm, KTH Royal Institute of Technology.
- Aughton, P. (2008), *Liverpool: a People's History*, 3rd revised edition. Lancaster: Carnegie Publishing.
- Conroy-Dalton, R., and Bafna, S. (2003). 'The syntactical image of the city: a reciprocal definition of spatial elements and spatial syntaxes'. In: Hanson, J. (ed.), *Proceedings of the Fourth International Space Syntax Symposium*. London: University College London
- Dennis, R. (2008), 'Urban modernity, networks and places'. In *History in Focus: The City*. Available at: <<https://www.history.ac.uk/jhr/Focus/City/articles/dennis.html>>
- Griffiths, S. (2009), 'Persistence and change in the spatio-temporal description of Sheffield Parish c.1750-1905'. In: Koch, D., Marcus, L. and Steen J. (eds.) *Proceedings of the Seventh International Space Syntax Symposium*. Stockholm, Sweden: Royal Institute of Technology (KTH).
- Griffiths, S. (2011) 'Temporality in Hillier and Hanson's theory of spatial description: some implications of historical research for space syntax'. In: *Journal of Space Syntax*, Vol. 2(1), p. 73-96
- Griffiths, S. (2012), 'The use of space syntax in historical research: current practice and future possibilities'. In: In: Greene, M., Reyes, J. and Castro, A. (eds.), *Proceedings of the Eighth International Space Syntax Symposium*, Santiago de Chile: PUC.
- Griffiths, S. (2013), 'GIS and research into historical "spaces of practice": overcoming the epistemological barriers'. In: von Lünen, A. and Travis, C. (eds.) *History and GIS: Epistemologies, Considerations and Reflections*, p.153-172. London: Springer.
- Griffiths, S. (2017, in press), 'Manufacturing innovation as spatial culture: Sheffield's cutlery industry c.1750-1900'. In: Van Damme, I., Blondé, B. and Miles, A. (eds.) *Cities and Creativity from the Renaissance to the Present*. Abingdon: Routledge.
- Hillier, B. (2007), *Space is the Machine, electronic edition*. Cambridge: Cambridge University Press.
- Hillier, B. and Hanson, J. (1984), *The Social Logic of Space*. Cambridge: Cambridge University Press.
- Hillier B., and Iida, S. (2005), 'Network and psychological effects in urban movement'. In: Cohn A. and Mark D. (eds.) *Spatial Information Theory*. COSIT 2005. Lecture Notes in Computer Science, Vol. 3693. Berlin: Springer-Verlag.
- Hillier, B. and Vaughan, L. (2007), 'The city as one thing.' In *Progress in Planning*, Vol. 67 (3), p.205-230.
- HMSO (1981), *The Scarman Report, Report Of An Inquiry By The Rt. Hon. The Lord Scarman, OBE*. London: Her Majesty's Stationery Office.
- Hobsbawm, E. (1962), *The Age of Revolution: Europe 1789-1848*. London: Weidenfeld and Nicholson.
- Ingold, T. (1993), 'The temporality of the landscape'. In *World Archaeology*, Vol. 25(2), Conceptions of Time in Ancient Society, p. 152-174.
- Jansen, H. (1996), 'Wrestling with the angel: on problems of definition in urban historiography'. In *Urban History*, Vol. 23(3), p. 277-299.
- Lawton, R. (1979), 'Mobility in Nineteenth Century British Cities'. In *The Geographical Journal*, Vol. 145(2), p. 206-224.
- LCC (2015), *The Index of Multiple Deprivation 2015: A Liverpool analysis*. Liverpool: Liverpool City Council.
- Lefebvre, H. (1991), *The Production of Space*, English translation by D. Nicholson-Smith. Oxford: Blackwell Publishing.
- Lynch, K. (1971), *The Image of the City*. Cambridge, MA: MIT Press.
- Massey, D. (1994), *Space, Place and Gender*. Cambridge: Polity Press.
- Medeiros, V. de Holanda, F. and Trigueiro, E. (2003), 'From compact colonial villages to sparse metropolis: investigating grid integration, compactness and form of the integration core in Brazilian cities'. In: Hanson, J. (ed.) *Proceedings of the Fourth International Space Syntax Symposium*, London: University College London.
- O'Brien, J. and Psarra, S. (2015), 'The dialogic city: towards a synthesis of physical and conceptual artefacts in urban community configurations'. In: Karimi, K., Vaughan, L. Sailer, K., Palaiologou, G. and Bolton. T. *Proceedings of the Tenth International Space Syntax Symposium*, London: University College London.

- SNAP (1972), *Another Chance for Cities: SNAP 69|72*. Liverpool: Shelter Neighbourhood Action Project.
- Sykes, O., Brown, J., Cocks, M., Shaw, D. and Couch, S. (2013), 'A city profile of Liverpool'. In *Cities*, Vol. 35, p.299–318.
- Tufte, E. (2006), *Beautiful Evidence*. Cheshire, CT: Graphics Press.
- Pinho, P. and Oliveira, V. (2009), 'Combining different methodological approaches to analyze the Oporto Metropolitan Area'. In: Koch, D., Marcus, L. and Steen, J. (eds.) *Proceedings of the Seventh International Space Syntax Symposium*, Stockholm, Sweden: Royal Institute of Technology (KTH).
- Pooley, C. (1977), 'The residential segregation of migrant communities in mid-Victorian Liverpool'. *Transactions of the Institute of British Geographers*, p.364-382.
- Pooley, C. (2000), 'Patterns on the ground: Urban form, residential structure and the social construction of space'. In: Daunt, M. (ed.) *The Cambridge Urban History of Britain 1840-1950*. Cambridge: Cambridge University Press, p.429-465.
- Pooley, C. (2016), 'Mobility, transport and social inclusion: Lessons from history'. In *Social Inclusion*, Vol.4(3), p. 100-109.
- Rodger, R. and Sweet, R. (2008), 'The changing nature of urban history'. In *History in Focus: The City*. Available at: <<https://www.history.ac.uk/ihr/Focus/City/articles/sweet.html> >
- Urry, J. (2004), 'The "system" of automobility'. In *Theory, Culture and Society*, Vol. 21(4/5), p. 25–39
- Vaughan, L. (2007), 'The spatial form of poverty in Charles Booth's London'. In: Vaughan, L. (ed.) *The Spatial Syntax of Urban Segregation*. Amsterdam: Elsevier
- Vaughan, L. and Penn, A. (2006), 'Jewish immigrant settlement patterns in Manchester and Leeds 1881', In *Urban Studies*, Vol. 43(3), p. 653–671.