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The Spatial Properties of Neighbourhood Public Open Spaces in the Tel-Aviv Metropolitan Area

Small- and large-scale integration and its impact on accessibility and service area

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ABSTRACT

This paper demonstrates the methods and results of our analysis of the “global” spatial properties of green Public Open Spaces (POS) in the Tel-Aviv metropolitan area. Global properties like centrality, integration and connectivity can influence the use and perception of green POS in multiple, complex ways. Identifying and categorizing these properties is a necessary prerequisite to understanding their influence. We therefore asked: What are the global configurational characteristics of these POS? How are they distributed and integrated spatially? How are their global properties related to their accessibility, as expressed in their service range?

We defined neighbourhood POS using the head/tail breaks classification method, then calculated the Angular Integration of the road network at different scales to identify significant variability trends by preforming Principal Components Analysis. This analysis revealed two distinct spatial accessibility systems - city-scale and neighbourhood-scale - which produced four spatial categories, representing different combinations of small-scale patterns and large-scale context. We found that approximately one third of the POS in the area are in low centrality on both scales, another third in high centrality on both, and the last third high on one scale but low on the other. The two categories with high integration values on the city-scale also had the largest service area, indicating more accessibility. Finally, the configurational categories are not evenly distributed across the spatial system, which may influence the diversity of locally available social functions. Selecting a representative sample of these POSs for detailed analysis is the next step towards exploring this.

KEYWORDS

Public Open Space, Integration Centrality, Accessibility, Spatial Analysis, Tel-Aviv Metropolitan Area

1 INTRODUCTION

Neighbourhood parks and boulevards, as green Public Open Spaces (POS), are the close-to-home physical part of the broad concept of public space (Mehta, 2014). Although public space has moved, in today's culture, to various private or virtual spaces (Banerjee, 2001), people still need the physical public space for social functioning, leisure activities, movement, shopping, play, meetings, interacting with other people and relaxation (Mehta, 2014). The neighbourhood parks and boulevards located in our immediate vicinity are the nearest green POS available to us (Chiesura, 2004; Peschardt and Stigsdotter, 2013).

The way we use and function in green POS is considerably influenced by our perceptions of their quality (Ewing and Handy, 2009; Rofè, Zarchin, and Feierstein, 2012). Although perception is affected by personal and social significance, and by personal sense-of-place, there are also some properties of the environment that are significant to everyone (Weinreb and Rofe, 2013). These properties, which are related to the POS's location within the urban network as well as their spatial configuration, can be classified respectively as Global and Local Spatial Properties (Franz and Wiener, 2008; Knöll *et al.*, 2015). The first category refers to the 'extrinsic properties' as defined within the space syntax method and calculated using topological graph-based analysis. The second, which relates to their shape and geometry, refers to 'intrinsic properties' that describe the spatial structure and spatial elements of POS (Van Nes and Yamu, 2021, p. 24-25).

The larger goal of our study is to examine the impact of both global and local spatial properties on the social functioning and personal benefits of neighbourhood POS. Within that context, this paper focuses on the analysis of the global spatial properties of the green POS in the Tel-Aviv metropolitan area, and asks the following questions: What are the global configurational characteristics of these green POS? How are they distributed and integrated spatially? How are the parks' global properties related to their accessibility, as expressed in their service range?

The connectivity and centrality of public spaces in the street network have been shown to have a strong impact on movement-related uses (Stahle, 2005; Ståhle and Caballero, 2010; Campos-Sánchez, Abarca-Álvarez and Reinoso-Bellido, 2019). Spatial patterns with higher integration and connectivity values generate movement (Hillier and Hanson, 1984), which in turn increases social interaction (Can and Heath, 2016) and co-presence (Legeby, 2013). Importantly, however, in the context of green POS, the effect of centrality on social functions can be more complex and ambivalent. When the POS is highly globally integrated, for example, it might be linked to feelings of anxiety, which have been associated with motor movement, noise and air pollution (Knöll *et al.*, 2015). Conversely, values of high connectivity and integration at the local level are associated with high walkability and accessibility to public life and have been found to reduce psychological distress (Sarkar, Gallacher and Webster, 2013). POS that are not in the most integrative areas, but close enough to them, may thus offer potential for different types of interactions and provide a place for relaxation (Koch, 2021).

There is a need for a more careful and nuanced approach when considering the location of green POS (Koch, 2021) and addressing centrality at different scales is part of the methodology proposed in this study. Our approach allowed us to identify POS that are very central, very local and those whose centrality changes with the scale, determine how this affects their accessibility and observe whether there is a scattering pattern in our spatial system. These outcomes can then be used to assess the potential social functions in different areas and help us select a sample for further study of how various POSs are used and perceived.

2 DATASETS AND METHODS

Green POS in the study area

The study area consists of the seven cities which form the core of the Tel Aviv Metropolitan Area in Israel. This area is separated from the surrounding metropolitan area by wide highways, which create a discontinuity in the urban fabric. Thus, the study's boundaries were determined there, and no buffer was used in the calculation (see fig.1B - municipal boundaries marked in blue). The sizes of the green POS are distributed in a heavy tail distribution, with many small POS and very few large ones. We therefore used the head/tail breaks classification method suggested by Jiang (2013) to define what would be considered a neighbourhood POS. We selected POS ranging from 100 sq.m. to 4.1 hectares, encompassing 98% of all the green POS. The green POS data set is based on uniform data from Israel Mapping Centre and OSM (Open Street Maps), validated against Tel Aviv Municipality data.

Road network data collection and analysis

The road network data were taken from the highway category of OSM, simplified to show Road Centre Lines (RCL) (Kolovou *et al.*, 2017; Krenz, 2017a). A Segment map was created using QGIS Desktop 3.14.0 and the Place Syntax Tool (PST) developed by KTH School of Architecture, Chalmers School of Architecture (SMoG) and Spacescape AB (Koch and Legeby, 2017; Ståhle *et al.*, 2018).

Using the PST, we calculated the Angular Integration (AI) of the road network in different radii of walking distances in meters, which was found to accurately represent movement flow (Omer and Kaplan, 2019). Since studies have found that walking distances to parks are up to 800m or 10 minutes' walk (Alexander *et al.*, 1977, p. 304; Thompson, 2002; Talen, 2003), we started the Angular Integration analysis within a local walking radius of 200m and gradually ascended to the global radius N. Next, each park was given an Angular integration value in the different radii. To reveal distinct spatial accessibility systems, we implemented Principal Components Analysis (PCA), and identified explanatory factors (Serra and Pinho, 2013; Krenz, 2017b; Kaplan, Burg and Omer, 2020), This was done using SPSS (IBM). The PCA test revealed two explanatory factors. Factor 1 highly correlates to the large urban (CITY) scales (800m to radius N), with radius 3000m showing the highest correlation with the CITY scale. Factor 2 highly correlates to the smallest neighbourhood (NBD) scales (200m-500m), with radius 250m having the highest correlation with the NBD scale (fig 1A).

Analysis based on the principle of high/low clusters was adopted to characterize the level of integration of each POS segment on both CITY and NBD scale. Then, based on the results, we classified the POS by categories of "high-NBD/high-CITY", "high-NBD/low-CITY", "low-NBD/high-CITY" and "low-NBD/low-CITY" (fig 1B).

To find clustering patterns for the different categories, we used PST 'Attraction Reach' to measure how many parks from each category can be reached from every segment within a walking distance of 800m (Koch and Legeby, 2017). Another way of evaluating accessibility is by measuring the service range of POS. To calculate this, we used PST 'Attraction Reach' (Koch and Legeby, 2017) to measure the total length of all reachable street segments from the POS within 400m walking distance. This measurement indicates how dense and interconnected the street network surrounding the POS is, with dense street pattern and connectivity translating into greater overall street length served by the POS.

3 RESULTS

Distribution of the multidimensional categories in the study area

The division into multidimensional categories showed that they are approximately evenly distributed into three groups (fig 1B, C). The "low-NBD/low-CITY" category is the largest, with

37% of the POS. The next group, “high-NBD/high-CITY,” represented another third, with 28% of the POS. The intermediate categories "high-NBD/low-CITY" and "low-NBD/high-CITY" are roughly equal in size and constitute the last 35% of the POS between them. This means that approximately one third of the POS are in low centrality at both the neighbourhood and city scale and another third is in high centrality on both scales, representing overlapping scales. The last third is high on one scale but low on the other, and they may offer potential for different social functions than in the overlapping scale POS.

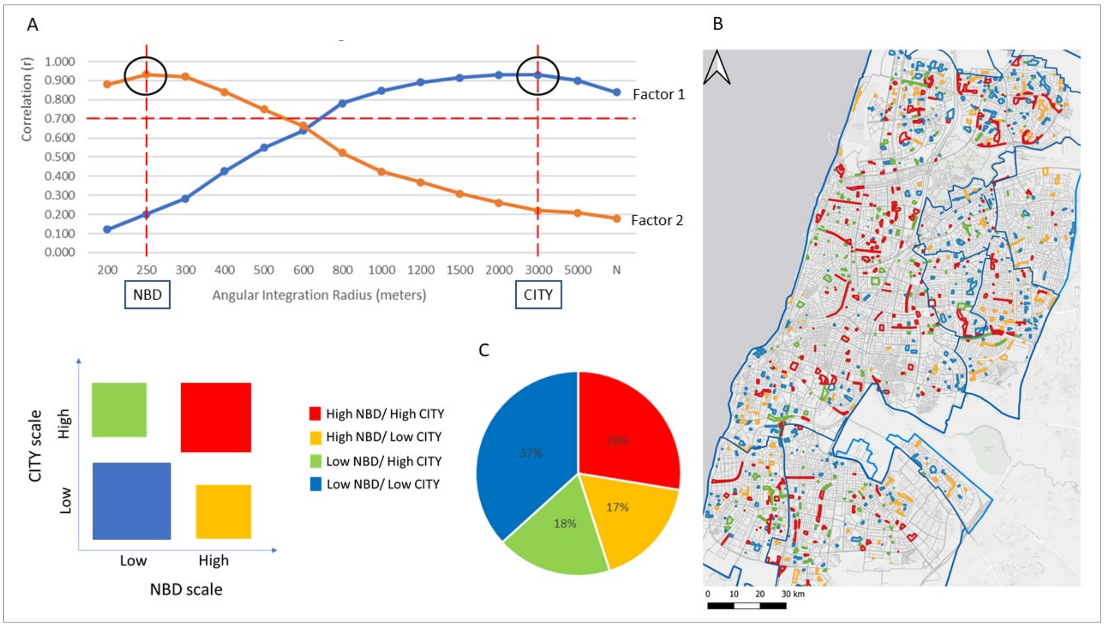

Figure 1: Classifying green POS according to spatial configurational characteristics

The results of the clustering pattern analysis revealed that the category “high-NBD/high-CITY” appears mainly in the centre of the spatial structure, where integration scales are overlap. Most of the “low-NBD/high-CITY” green POS are in that area too, reflecting places with metropolitan integration that are nevertheless isolated locally. The “low-NBD/low-CITY” POS are located primarily in the peripheral areas, isolated on both scales, and the “high-NBD/low-CITY” POS are in those areas too, but integrative at the local level (fig 2). This clustering pattern suggests that there are differences in global spatial properties of POS at different locations in the spatial system, which may influence the diversity of available social functions at those places.

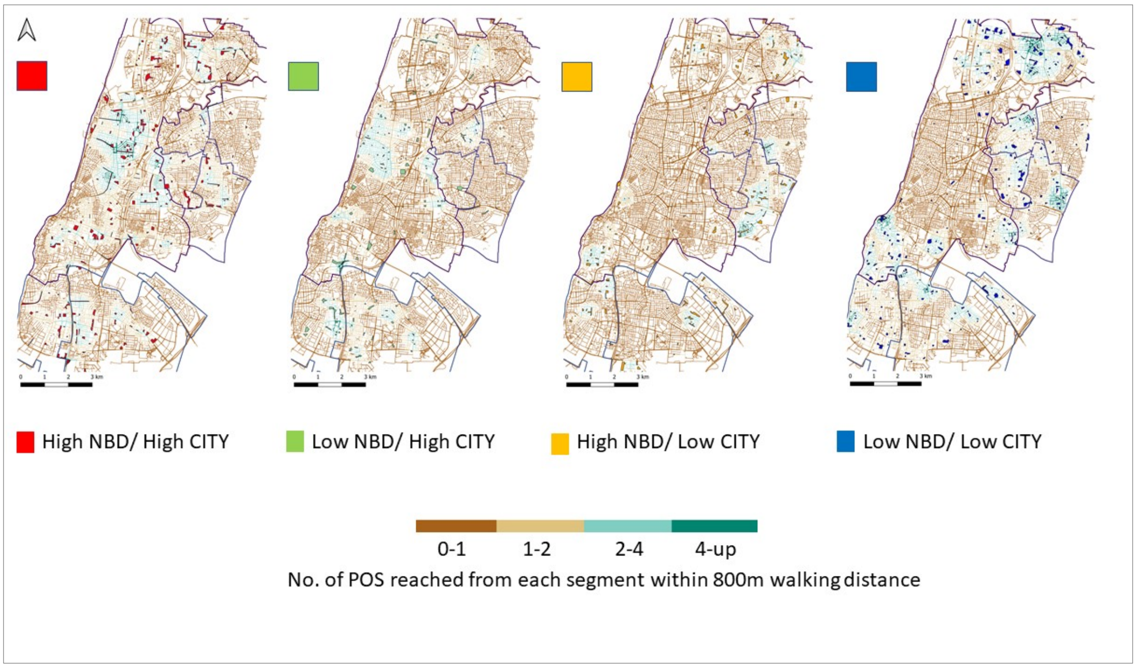

Figure 2: The clustering patterns of the green POS types

Spatial configurational characteristics and service area

We calculated the service area for all the POSs in the sample area and divided the results into three categories – high (1516m and up of street length), medium (between 840m-1516m) and low (up to 840m) (fig 3A). In the "high-NBD/high-CITY" category, 27% of the parks fell into the high range, 40% into medium and 33% had a very low service area. The "low-NBD/high-CITY" category showed a similar division, with 20% high, 42% medium and 38% low. The "low-NBD/low-CITY" category had the lowest service area, with only 7% of the parks in the highest service bracket (fig 3B). Analysis of the POS with the highest service area showed that almost half of them (49%) are from the "high-NBD/high-CITY" category and nearly a quarter (24%) are from the "low-NBD/high-CITY" category (fig 3C). Therefore, service area seems to be associated with the POS's Angular Integration at the large city scale, since the two categories that have high integration values in that scale are the two with the largest service area. Both categories are mainly found in the centre of the spatial system, where the street pattern is denser and more interconnected, so their service area is higher, and they are more accessible.

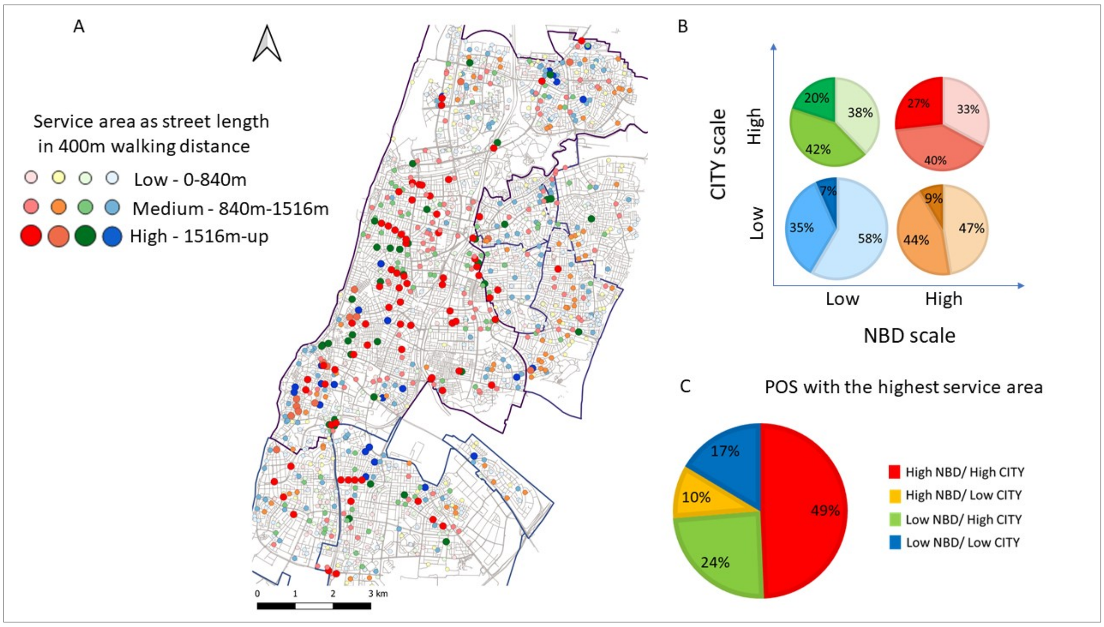

Figure 3: The relations between configurational characteristics and service area of the POS

4 CONCLUSIONS

The multidimensional categories express the degree of the POS's integration in the closest local network, but also as related to, and influenced by, the urban network as a large system. The structure of the streets, and the location of the POS within that structure, greatly influence a person's ability to reach POS on a daily walk. In our research area, it seems that the central areas have a more integrative network so that POS there gain more accessibility and serve a larger area. Moreover, the configurational categories are not evenly distributed across the entire spatial system. If different categories generate potential for different social functions, this is a first step towards mapping them and gaining a better understanding of how they are distributed and integrated spatially in the study area. This step will help us to choose a representative sample of POSs for detailed analysis to explore how they are used and perceived.

REFERENCES

Alexander, C. *et al.* (1977) *A Pattern Language*. New York: Oxford University Press.

Banerjee, T. (2001) 'The future of public space: Beyond invented streets and reinvented places', *Journal of the American Planning Association*, 67(1), pp. 9–24. doi: 10.1080/01944360108976352.

Campos-Sánchez, F. S., Abarca-Álvarez, F. J. and Reinoso-Bellido, R. (2019) 'Assessment of open spaces in inland medium-sized cities of eastern Andalusia (Spain) through complementary approaches: spatial-configurational analysis and decision support', *European Planning Studies*. Taylor & Francis, 0(0), pp. 1–21. doi: 10.1080/09654313.2019.1579302.

Can, I. and Heath, T. (2016) 'In-between spaces and social interaction: a morphological analysis of Izmir using space syntax', *Journal of Housing and the Built Environment*, 31(1), pp. 31–49.

doi: 10.1007/s10901-015-9442-9.

Chiesura, A. (2004) 'The role of urban parks for the sustainable city', *Landscape and Urban Planning*, 68(1), pp. 129–138. doi: 10.1016/j.landurbplan.2003.08.003.

Ewing, R. and Handy, S. (2009) 'Measuring the unmeasurable: Urban design qualities related to walkability', *Journal of Urban Design*, 14(1), pp. 65–84. doi: 10.1080/13574800802451155.

Franz, G. and Wiener, J. M. (2008) 'From space syntax to space semantics: A behaviorally and perceptually oriented methodology for the efficient description of the geometry and topology of environments', *Environment and Planning B: Planning and Design*, 35(4), pp. 574–592. doi: 10.1068/b33050.

Hillier, B. and Hanson, J. (1984) *The social logic of space*. New York: cambridge university press. doi: 10.1016/0169-2046(86)90038-1.

Jiang, B. (2013) 'Head/Tail Breaks: A New Classification Scheme for Data with a Heavy-Tailed Distribution', *Professional Geographer*, 65(3), pp. 482–494. doi: 10.1080/00330124.2012.700499.

Kaplan, N., Burg, D. and Omer, I. (2020) 'The spatial organization of accessibility and functional hierarchy: The case of Israel', *Computers, Environment and Urban Systems*. Elsevier, 80(October 2019), p. 101429. doi: 10.1016/j.compenvurbsys.2019.101429.

Knöll, M. *et al.* (2015) 'Using space syntax to analyse stress ratings of open public spaces', *10th International Space Syntax Symposium*, pp. 1–15.

Koch, D. (2021) 'Relative rhythms, urban oases, and spatial resilience / Exploring syntaxes of seclusion, solitude, and tranquility', *Journal of Design for Resilience in Architecture and Planning*, 2(special issue), pp. 56–73. doi: 10.47818/drarch.2021.v2si035.

Koch, D. and Legeby, A. (2017) 'WORKSHOP 6 - PST with QGIS as base 12th Space Syntax Symposium in Beijing , Monday July 8 , 13 : 30 TUTORIAL 1 – PST with QGIS as base Getting started To download QGIS Installing PST in QGIS Opening a map in QGIS', pp. 1–14.

Kolovou, I. *et al.* (2017) 'Road centre line simplification principles for angular segment analysis', *Proceedings - 11th International Space Syntax Symposium, SSS 2017*, (July), pp. 163.1-163.16.

Krenz, K. (2017a) 'Employing volunteered geographic information in space syntax analysis', *Proceedings - 11th International Space Syntax Symposium, SSS 2017*, (January), pp. 150.1-150.26.

Krenz, K. (2017b) 'The Emergence of Spatial Scales in Urban Regions', *Proceedings of the 11th Space Syntax Symposium #74*, pp. 74.1-74.23. Available at: http://www.11ssslisbon.pt/docs/proceedings/papers/74.pdf.

Legeby, A. (2013) *Patterns of Co-presence: Spatial Configuration and Social Segregation*, *Space Syntax*. Royal Institute of Technology Stockholm Sweden.

Mehta, V. (2014) 'Evaluating Public Space', *Journal of Urban Design*. Taylor & Francis, pp. 53–88. doi: 10.1080/13574809.2013.854698.

Van Nes, A. and Yamu, C. (2021) *Introduction to Space Syntax in Urban Studies*. Cham, Switzerland: Springer Nature Switzerland AG.

Omer, I. and Kaplan, N. (2019) 'Structural properties of the angular and metric street network's centralities and their implications for movement flows', *Environment and Planning B: Urban Analytics and City Science*, 46(6), pp. 1182–1200. doi: 10.1177/2399808318760571.

Peschardt, K. K. and Stigsdotter, U. K. (2013) 'Associations between park characteristics and perceived restorativeness of small public urban green spaces', *Landscape and Urban Planning*. Elsevier B.V., 112(1), pp. 26–39. doi: 10.1016/j.landurbplan.2012.12.013.

Rofè, Y., Zarchin, I. and Feierstein, G. (2012) 'Quantity and quality of public open spaces in Israel', *Proceedings of the ICE - Urban Design and Planning*, 165(3), pp. 177–187. doi: 10.1680/udap.11.00021.

Sarkar, C., Gallacher, J. and Webster, C. (2013) 'Urban built environment configuration and psychological distress in older men: Results from the Caerphilly study', *BMC Public Health*. BMC Public Health, 13(1), p. 1. doi: 10.1186/1471-2458-13-695.

Schipperijn, J. (2010) 'Use of urban green space', *Forest & Landscape Research*, (February 2010), pp. 45–2010.

Serra, M. and Pinho, P. (2013) 'Tackling the structure of very large spatial systems - Space syntax and the analysis of metropolitan form', *Journal of Space Syntax*, 4(2), pp. 179–196.

Stahle, A. (2005) 'Park syntax: Measuring open space accessibility and "smart growth"', *Space Syntax 5th International Symposium, Vol 2, Proceedings*, (Usk), pp. 779–780.

Ståhle, A. *et al.* (2018) *PST Documentation*.

Ståhle, A. and Caballero, L. (2010) 'Greening metropolitan growth: integrating nature recreation, compactness and spaciousness in regional development planning', *International Journal of Urban Sustainable Development*, 2(1–2), pp. 64–84. doi: 10.1080/19463138.2010.512496.

Talen, E. (2003) 'Neighborhoods as service providers: A methodology for evaluating pedestrian access', *Environment and Planning B: Planning and Design*, 30(2), pp. 181–200. doi: 10.1068/b12977.

Thompson, C. W. (2002) 'Urban open space in the 21st century', *Landscape and Urban Planning*, 60(2), pp. 59–72. doi: 10.1016/S0169-2046(02)00059-2.

Weinreb, A. R. and Rofe, Y. (2013) 'Mapping Feeling: an Approach To the Study of Emotional Response To the Built Environment and Landscape', *Journal of Architectural and Planning Research*, 30(2), pp. 127–145.