Configurational Accessibility in Practice: Integration, Choice, and the Clustering of Activity Spaces in Beşiktaş, Istanbul

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1 Introduction

The pursuit of sustainable urban environments is an ongoing challenge for urban planners and designers globally. Modern planning increasingly prioritizes pedestrian mobility and reduced car dependency. To this end, a variety of methodologies including GIS, statistical analysis, and space syntax, have been traditionally employed to understand and predict pedestrian movement and urban dynamics (Hillier & Hanson 1984, Hillier 2007). However, as urban landscapes continue to evolve, a more holistic understanding of socio-spatial dynamics necessitates integrating diverse data sources. This research extends previous explorations by integrating location-based social network (LBSN) data, specifically Foursquare venue data, with Space Syntax measures to gain a deeper, more nuanced understanding of urban socio-spatial dynamics in Beşiktaş, Istanbul, Türkiye. The primary objective is to investigate the intricate relationship between the distribution of activity spaces and the characteristic features of the street network, exploring the potential of social network data in conjunction with Space Syntax as a comprehensive analytical framework (Iranmanesh & Atun 2020, Üsküplü et al. 2020). This study seeks to address how social media reflects socio-spatial dynamics, the impact of the urban physical network on these dynamics, and the complex

interplay between LBSN data and syntactic measures. Ultimately, this research aims to contribute valuable insights for creating more pedestrian-friendly and livable urban spaces, emphasizing the critical importance of integrating spatial configuration analysis with real-time social activity data to better align urban environments with residents' needs and preferences (Yamu et al. 2021). This approach offers a fresh perspective on how the physical layout of a city shapes its social and economic life.

2 Methods

The methodology for this research involved four sequential phases. Firstly, data collection encompassed two main sources: Foursquare venue data and Open Street Map (OSM) road network data. Foursquare venue data for Beşiktaş district was collected via the Foursquare API database, ensuring comprehensive coverage by dividing the case area into square cells and conducting multiple searches for various venue categories. This yielded a dataset of 1320 venues, categorized into Recreation and Entertainment, Dining and Drinking, and Retail, after an initial categorization and subsequent merging based on functional similarity and numerical representation. The raw JSON data was converted to CSV and then mapped in ArcGIS Pro (Bernabeu-Bautista et al. 2021). Secondly, for the Space Syntax analyses, street network data (road center lines) were extracted from OSM. To mitigate the "edge effect" problem in syntactic analyses, a frame larger than the specific case area was defined (Peponis et al. 1997). Pedestrian pathways not visible in the initial road center lines map were identified using satellite imagery and incorporated into the map in ArcGIS Pro. An axial map (N=1640) was then prepared and subsequently broken into a segment map using DepthmapX software for spatial element analysis (Turner 2004).

In the third phase, Kernel Density Estimation (KDE) was applied to the Foursquare venue data to visualize the spatial distribution and clustering of activity spaces. KDE, a non-parametric algorithm, was used to generate continuous density surfaces for all venues as well as for the individual categories of Dining and Drinking, Recreation and Entertainment, and Retail (Wilson & Gerard 2019). This allowed for the identification of significant activity hotspots within the district. Concurrently, Space Syntax analyses were performed using DepthmapX to derive syntactic measures specifically "to-movement" (integration) and "through-movement" (choice) values. These analyses were conducted at both global (r=n) and local (r=50m, 250m, 500m) scales with a focus on global analyses for their superior capture of the area's distinctive features (Hillier & Iida 2005). Integration

values quantify the connectivity of each street segment to the overall system, indicating its potential as a "target point" (Klarqvist 1993). Choice values, on the other hand, evaluate the potential for a street to be used as a shortcut, reflecting through-movement (Turner 2007).

The fourth and final phase involved the superimposition of the Kernel Density Analysis results with the Space Syntax measures. This crucial step allowed for a comparative evaluation of the spatial distribution of venues against the integration and choice values of the street network. By visually overlaying these two layers of data, the research aimed to reveal correlations and discrepancies between physical accessibility and social activity patterns, providing a holistic perspective on the socio-spatial dynamics of Beşiktaş.

3 Results

The Kernel Density Analysis revealed significant clustering of venues around Sinan Paşa Mosque, particularly at the intersection of Beşiktaş Street and OrtaBahçe Street, with high densities also observed in Cihannüma, Akaretler, and Vişnezade districts. Dining and drinking venues showed the most significant density around Beşiktaş Square, a central hub of the Beşiktaş Çarşı district, as well as in the areas between Barbaros Boulevard and Akmazçeşme Street, near Sinan Paşa Mosque, and in Akaretler. Recreation venues formed notable densities in Beşiktaş Pier, Maçka Square, and Akaretler. In contrast, retail venues exhibited a distinct characteristic, clustering primarily in the inner parts of Beşiktaş Street following Ortabahçe Street, with very low densities elsewhere. This suggests a more concentrated pattern for retail compared to the dispersed distribution of dining and drinking venues.

The Space Syntax integration analysis indicated that Beşiktaş Street, Barbaros Boulevard, and Dolmabahçe Street possessed the highest global integration values within the study area. These highly integrated axes, particularly Barbaros Boulevard and Dolmabahçe Street, frame the Çarşı district, reinforcing its interconnectedness and overall accessibility (Hillier & Hanson 1984). Within the Çarşı district itself, Ortabahçe Street, Şair Nedim Street, and Süleyman Seba Street also showed relatively high integration, attributed to the dense street network. Variations in integration levels across Barbaros Boulevard were noted, with the denser road network on the Çarşı district side contributing to higher connectivity, while the eastern side, characterized by hilly terrain and larger land parcels, exhibited lower integration due to disconnected visual representation and dead-end streets.

The choice analysis highlighted Barbaros Boulevard, Çırağan Street, Hasfırın Street, OrtaBahçe Street, Ihlamurdere Street, Hattat Tahsin Street, and Şht. Asım Street as having the highest choice values, suggesting their strong potential as preferred routes for through-movement (Hillier 2008). A key finding was the predominantly north-south alignment of higher choice values across Beşiktaş. The Beşiktaş Çarşı district generally showed low choice values, with the highest concentrations near Ortabahçe Street, Ihlamurdere Street, and Barbaros Boulevard. Has Fırın Street stood out as the main axis within the district with a distinctly higher choice value, despite the overall low choice values in high pedestrian traffic areas.

The superimposition of venue density with integration values revealed a strong positive relationship for streets such as Barbaros Boulevard, Beşiktaş Street, Ortabahçe Street, and Şair Nedim Street (Figure 1). These thoroughfares, characterized by high integration, align with the natural movement theory, attracting a high concentration of venues and pedestrian traffic due to their accessibility (Hillier et al. 1992). Süleyman Seba Street showed a moderate positive relationship, suggesting its role as a local connector supporting a balanced urban mix. However, some areas like Şht. Asım Street and the vicinity of Beşiktaş pier, exhibited high venue densities despite lower integration values. This suggests the presence of strong local character or constraints on through-movement in these areas.

Figure 1

When superimposing venue density with choice values, Barbaros Boulevard, Hasfırın Street, Ortabahçe Street, Ihlamurdere Street, and Hattat Tahsin Street showed high choice values, indicating their preference as routes and potential as vibrant commercial areas. Çırağan Street also demonstrated high choice values, but with lower venue density, potentially pointing to underutilization for commercial purposes compared to the Çarşı district. Interestingly, areas

with high venue density, such as the Vişnezade district and Süleyman Seba Street, showed lower choice values, suggesting local activity hubs that serve the immediate community rather than attracting significant through-movement. This indicated that while physical accessibility (integration) often correlates with activity, other factors influence venue distribution and usage.

4 Discussion and Conclusion

This research offers a critical perspective on understanding urban socio-spatial dynamics by integrating location-based social network data with syntactic measures in Beşiktaş, Istanbul. The findings reveal significant correlations between the syntactic properties of street networks and the distribution of activities and venues. Streets with high integration values, such as Barbaros Boulevard and Beşiktaş Street, tend to host popular venues and attract high pedestrian traffic, supporting the hypothesis that well-integrated streets are more likely to foster commercial activities. This directly addresses how the built form of urban areas shapes accessibility and performance, showing that spatial patterns can support or undermine broader development trends. The relationship between these elements underscores the importance of permeability and proximity in shaping urban vitality.

However, the study also uncovered instances where high venue densities did not consistently correspond with high integration or choice values. This discrepancy, observed in areas like Şht. Asım Street and parts of the Çarşı district, suggests that factors beyond mere spatial configuration, such as cultural or historical significance, local community needs, or even virtual connections that draw people to less accessible physical spaces, also play a crucial role in shaping activity distribution (Iranmanesh & Alpar Atun 2017). This highlights that while proximity and permeability are fundamental, they are not the sole determinants of urban vibrancy and inclusion. It prompts a re-evaluation of how spatial relationships really shape mobility and land use, acknowledging the complexity introduced by social and cultural layers.

The integration of Foursquare data provides a valuable, real-time, and cost-effective lens into user behavior and preferences, complementing the structural insights from Space Syntax (Kitchin 2014, Martí et al. 2019). This multi-layered approach enriches our understanding of how spatial organization facilitates or restricts movement and interaction. For urban planners and designers, these findings emphasize the necessity of considering both the inherent physical characteristics of the street network and the dynamic social behaviors captured by LBSN

data when designing pedestrian-friendly and livable spaces. It suggests that interventions aimed at enhancing urban permeability and proximity should be informed by a comprehensive understanding of where people actually congregate and why, moving beyond purely geometric considerations.

One limitation of this research is its reliance solely on Foursquare data, which may not fully represent all socio-spatial activities and could be subject to demographic biases. Future studies could incorporate data from multiple social media platforms (Shelton et al. 2015) as well as qualitative methods like surveys and interviews, to provide deeper insights into the socio-spatial patterns and the human dimension behind them. Expanding the study to other districts or cities in Istanbul and beyond could also validate the generalizability of these findings. Additionally, incorporating other socio-spatial, economic, and natural factors, such as topography and land-use data, could provide a more holistic understanding of urban dynamics. Nevertheless, this study underscores that a combined approach, integrating crowdsourced data with established spatial analysis techniques, is vital for a comprehensive understanding of how physical environments shape and are shaped by urban interactions, making significant contributions to the discourse on proximity, permeability, and accessible urban design.

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