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Cultural heritage attractors: does spatial configuration matter? Applications of macro- and micro-spatial configurative analysis in the historic urban area of Rome

Sophia Arbara, Akkelies van Nes and **Ana Pereira Roders**
E-mails: s.arbara@tudelft.nl, Akkelies.van.Nes@hvl.no, a.r.pereira-roders@tudelft.nl
Orcids: 0000-0002-0324-2094, 0000-0002-3663-0157, 0000-0003-2571-9882

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Abstract. *Top world heritage artifacts act as pedestrian flow attractors in historic urban areas. Despite the growing literature on pedestrian movement in cities, evidence of the relationship between cultural attractors and the spatial characteristics of street spaces between these artifacts is scarce. This contribution applies the theory of natural movement and uses diachronic space syntax and micro-spatial analysis to investigate the reciprocities between street networks and the presence of global heritage attractors in the historic urban area of Rome. The results from the macro-scale spatial analyses show good correlations between the current most popular cultural attractors and the global integration of the street network. The degree of spatial integration of the street network is particularly important at the time of construction of important artifacts, as shown in the diachronic analyses. City growth and urban transformation can affect the central position of these important artifacts. However, in the case of highly attractive artifacts, these continue to perform as movement attractors. The result of a local neighbourhood investigation shows that micro-spatial parameters, such as the spatial relationships between building entrances and streets, may influence the choice of routes between important artifacts. Thus, the flows of people's movement can be influenced by both micro-spatial street characteristics and spatial configuration.*

Keywords: cultural heritage attractors, natural movement, space syntax, building-street interface

Globally-renowned cultural heritage artifacts act as pedestrian flow attractors, especially in the historic areas of the world's most visited cities. In 2019, for example, more than seven million people visited the Eiffel Tower in Paris, as well as the Coliseum and the Palatine Hill in Rome; and more than four million visited the Statue of Liberty in New York. The high number of visitors in areas of popular heritage attractors became a subject of study for a series of disciplines including urban studies. In this context, theoretical frameworks and policies emerged with the aim to address, monitor and eventually ease pressure from historic centres (Amore *et al.*, 2020). The discussion about recommendations, urban policies, and economic models for a holistic and more sustainable management of historic urban landscapes is growing (Bandarin and van Oers, 2012; Lerario and Di Turi, 2018; Rey-Pérez and Pereira Roders, 2020). However, empirical studies in urban planning investigating the underlying spatial conditions that influence the popularity of certain heritage attractors over others in historic areas are scarce, as are studies analysing

Contact: Sophia Arbara, Department of Urbanism, Delft University of Technology, Julianalaan 134, 2628 BL Delft, Netherlands and Department of Architecture, Roma Tre University, Via della Madonna dei Monti, 40, 00184 Rome, Italy. Akkelies van Nes: Department of Civil Engineering, Western Norway University of Applied Sciences, Inndalsveien 28, 5063 Bergen, Norway. Ana Pereira Roders, Department of Architectural Engineering and Technology, Delft University of Technology, Julianalaan 134, 2628 BL Delft, Netherlands.

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the characteristics of the streets which link sites of global cultural importance (Kong and Karimi, 2019).

The aim of this study is to investigate how various spatial conditions can affect the cultural trajectories present in historic urban areas. What role does present and past spatial configuration play in the popularity of heritage attractors? Moreover, what additional insights do the micro-spatial conditions, such as the building-street interface, offer on how contemporary cultural itineraries are shaped in historic urban areas? The objectives of this research are twofold: to examine potential correlations amongst the historical evolution of street network configuration and the position of cultural heritage attractors on a macro scale, and to explore the correlations between the presence of micro-spatial variables and the visitor's selection of routes when navigating through heritage attractors.

For the first part of this inquiry, the natural movement theory (Hillier *et al*., 1993) and various space syntax approaches are applied as a framework to explore how spatial configuration links to the location of global heritage attractors and movement. Then, the macro-spatial configuration of the street network is compared to the micro spatial variables (van Nes and López, 2010; van Nes and Yamu, 2021).

Background

Three different but complimentary approaches or research traditions for analysing the physical aspects of built environments exist: the urban morphology, the place phenomenology, and the urban network or spatial configurative tradition. Each addresses different aspects of the physical elements of a built environment (van Nes and Yamu, 2021).

The urban morphology tradition consists primarily of the three following schools: the Italian, the Versailles, and the Anglo-Saxon (Moudon, 1997). The common focus of their approach is to understand the drivers behind the change of urban pattern through societal changes. The elements of their approach consist of building shapes and their open spaces (plots, lots, and street form) which shape the urban form at a building, block, neighbourhood and city scale. Since this tradition studies continuous urban transformation, it focuses on the present context in relation to the city's history (Moudon, 1997, p. 5).

In recent years, quantitative methods have been developed within the urban morphology research tradition. Examples include the Spacematrix method, originally developed by Johan Rådberg in the 1980s (Rådberg, 1988, 1996; Berghauser Pont and Haupt, 2023) and the Function Mixture method (MXI) from Joost van der Hoek in 2008 (van den Hoek, 2008). Spacematrix quantifies building forms and building shapes, whereas the MXI method quantifies the degree of land use mix in urban areas.

The most widely-known scholars from the place phenomenology tradition are Christian Norberg Schulz (1980), Kevin Lynch (1960) and David Seamon (2015). Their approach consists of a qualitative description of the sphere of the built environment, descriptions of a place's character, and the meaning of the artifacts in relation to the sphere of the place (van Nes and Yamu, 2021, pp. 11–13). Currently, the most-used analysis method is the cognitive map of Kevin Lynch. Attempts have been made to generate place analyses based on Norberg-Schulz's work. However, they are criticized as being rather subjective (Karimi, 1998).

The spatial configurative approach is mostly developed in the UK with the work of Stephen Marshall (2004), Mike Batty (2007), and the work of Bill Hillier and his colleagues at UCL (Hillier, 1996; Hillier *et al*., 2012; Hillier and Hanson, 1984). The focus is on urban space instead of urban form. Whereas Marshall focuses on street pattern, Batty and Hillier focus on street structures and spatial configurations. Compared to other configurative approaches, the space syntax method, developed throughout the years by Hillier and his colleagues, has undergone the most significant changes since the 1970s, influenced by software development, computer capacities and open-source data accessibility

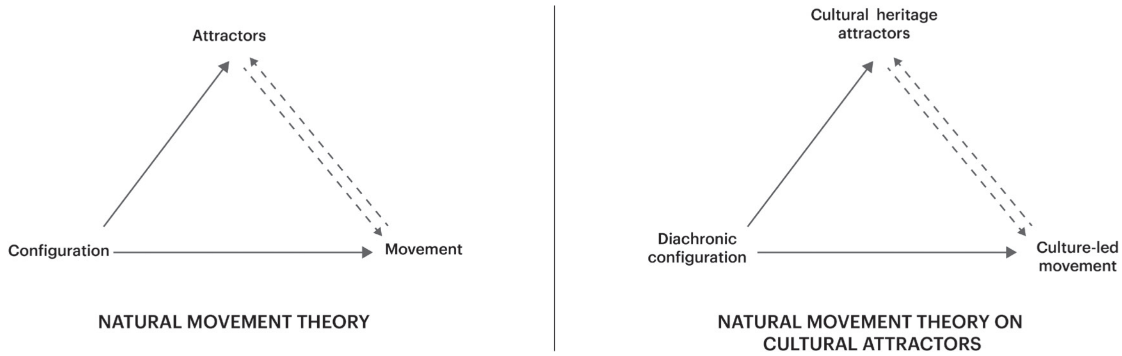

Figure 1. The theory of natural movement in relation to cultural heritage attractors (source: Arbara, 2022).

(van Nes and Yamu, 2021). Currently, space syntax research has contributed to the following theories: the theory of natural movement (Hillier *et al.*, 1993), the theory of the natural movement economic process (Hillier, 2001; van Nes, 2021), the theory of spatial combinatorics (Hillier, 1996), and the theory of the natural urban transformation process (Ye and van Nes, 2014).

Research on important historic artifacts mostly deals with the intrinsic properties of space. It is often referred as building form and meaning (Marcus, 2000). According to Hillier (1999), intrinsic properties of space are directly visible, such as the shape, size, volume, geometric properties, texture, and pattern of physical objects in built environments. Obviously, historically important artifacts can be seen immediately. Often, important artifacts are defined as 'primary elements' in the urban morphology tradition that has constituted the transformation of urban areas throughout history (Rossi, 1982). From a place phenomenology tradition, the role of important historic artifacts in contributing to the sphere and identity of a place is often discussed (Norberg-Schulz, 1980).

Regarding the relationship between important historic artifacts and their location in built environments, the focus is on the extrinsic properties of space. This concerns where these types of artifacts were located when they came into being and where they are located in the current urban context. Moreover, the way in which visitors orientate themselves through urban space to find these artifacts deals also with extrinsic properties. At present, there is a wide range of literature describing the architectural or artistic value of the design of important historic artifacts. However, research so far falls short regarding the role of spatial configuration in built environments on historic artifacts.

The natural movement theory linked to cultural heritage attractors

The theory of natural movement states that the primary generator of attraction points and movement in cities is the spatial configuration of the urban system. The main principles of the natural movement theory are based on the premise that a street network's spatial configuration influences attractors and movement, yet the position of attractors and movement patterns cannot influence spatial configuration (see Figure 1) (Hillier *et al.*, 1993). The natural movement theory provides an important framework linking space syntax theory and topological relations of the network *per se* to attractions and land use (Koohsari *et al.*, 2019).

The natural movement theory has been tested in correlation to various parameters in urban planning and design. Empirical studies have shown correlations between spatial configuration, commercial land uses, and pedestrian movement (Porta *et al.*, 2012, p. 201; Scoppa and Peponis, 2015; Liu *et al.*, 2016;

Omer and Goldblatt, 2016; van Nes, 2021). Although the concept of attractors mainly refers to economic ones, recent research examines the natural movement theory and attractors in relation to densification strategies in cities (de Koning *et al*., 2020), transport nodes (Koohsari *et al*., 2019), cultural heritage sites (Kong and Karimi, 2019) and historic settlements (van Nes, 2011). The natural movement theory has a high degree of predictability (van Nes and Yamu, 2020), making it useful in the regeneration of urban areas (van Nes and Yamu, 2021). The concept of natural movement has been developed further into the theory of the natural urban transformation process (Ye and van Nes, 2014).

The natural movement theory is not explicitly limited to economic attractors and commercial land uses but could involve other types of attractors, such as heritage clusters, religious and administrative buildings (Vaughan and Sailer, 2017). The present study aims to expand and examine possible applications of the natural movement theory in relation to cultural attractors (Arbara, 2022). Here, cultural heritage attractors are defined as built heritage properties including important architectural buildings, archaeological sites, and monuments excluding historic neighbourhoods or larger urban areas.

Heritage urbanism: a space syntax approach

According to space syntax research, a theoretical and empirical linkage between socio-economic activities and the spatial aspects of built environments has been well established (Pafka *et al*., 2020). Yet this field is less defined in heritage studies (Obad Šćitaroc *et al*., 2019; Palaiologou and Griffiths, 2019). Until recently, the field of cultural heritage studies has been studied primarily through the lens of heritage conservation (Veldpaus *et al*., 2013). UNESCO's Recommendation on the Historic Urban Landscape provided a new direction to heritage management, aiming to integrate urban conservation and urban development (UNESCO, 2011; Bandarin, 2019). Definitions and approaches such as "heritage urbanism" (Higueras Garcia, 2019; Obad Šćitaroc *et al*., 2019), "heritage planning" (Nadin *et al*., 2015), "landscape-based approaches" (Veldpaus *et al*., 2013), and "heritage urbanism syntax" (Palaiologou and Griffiths, 2019) emerged, seeking to link heritage research to urban studies. Space syntax could eventually provide an integrative framework for a dialogue between heritage studies and urbanism.

Methodology

Figure 2 presents the methods used in this inquiry. The study area is the historic urban area of Rome. It consists of hundreds of world-renowned cultural heritage sites ranking amongst the 20 most-visited cities in the world (Gemmiti, 2019). It is delimited by the Aurelian walls and is part of UNESCO's World Heritage Site (Mandich, 2019). The macro-analysis refers to the street network in the entire historic urban area of Rome, whereas the micro-analysis explores spatial attributes between the building-street interface of the three routes connecting two of the most visited global heritage attractors in Rome, the Trevi Fountain and the Pantheon. Macro- and micro-spatial elements are not seen as separate but as interrelated to one another, and a combination of these methods allows us to minimize the limitations that each method entails.

Integration and choice analyses from space syntax are performed on three chronological periods, characteristic for the evolution of the city of Rome, and the relation of each of the street networks to the city's cultural heritage attractors is historically examined. Subsequently, we focus on the Trevi–Pantheon routes with the aim to explore how the micro spatial variables relate to culture-led movement and the macro spatial conditions.

Macro spatial conditions: diachronic space syntax analysis

A diachronic analysis becomes relevant when studying the location of cultural heritage

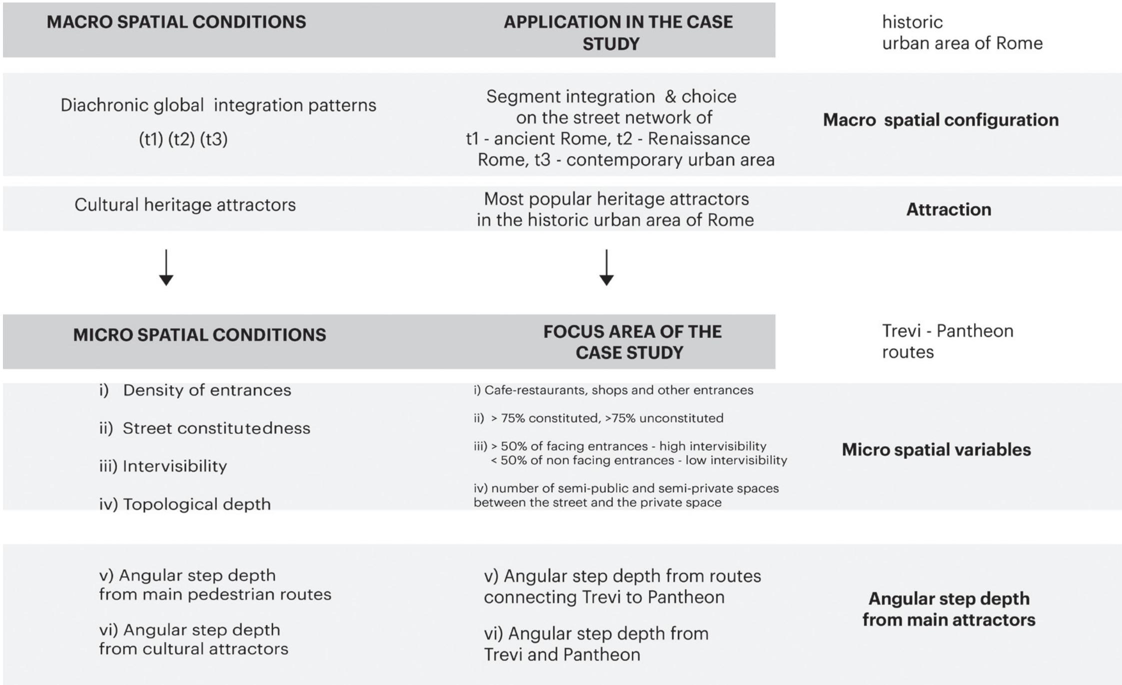

Figure 2. Methodological overview

attractors for two reasons. First, it allows understanding the centrality of these attractors within each urban setting and, secondly, it permits drawing references on the topological relations of historic periods and the use of attractors before these became cultural artifacts. In the case of Rome, the emergence of the first attractors occurred during the time of the Roman Empire, and a space syntax analysis divided into three broad, yet representative chronological periods is suggested (Sanfilippo, 1992).

The chronological periods are the following: (t1) for Ancient Rome, (t2) for Renaissance Rome and (t3) referring to the Contemporary historic urban area. The axial maps for each period were produced by retracing important maps of each selected period (Arbara, 2022). For (t1), the cartographic representation was based on the ancient street system represented by Lugli and Gismondi (1949). For (t2), the street network was reconstructed following Nolli's representation (Nolli, 1748), and for (t3), we obtained the map based on the OpenStreetMap database. While it is important to distinguish between modern Rome before the emergence of the automobile and after, this study limits the inquiry to the broader historical frames and thus this comparison falls beyond the scope of the present analysis.

Subsequently, the current 100 most popular attractors were identified based on open data from TripAdvisor and categorized according to traveller favourites (Arbara *et al.*, 2021). The cultural attractors were then added to each of the three chronological maps, depending on their time of emergence, and ranked based on popularity (1 to 100). As larger urban areas and artifacts located outside the case study area were excluded, the final sample was limited to 75 attractors (Table 1). Certain important attractors, such as St Peter's Square, are included into the spatial analysis, but not discussed in the results. The reason behind this is that these attractors are located in the boundaries of the present study area. The edge effect in the analyses might distort the results of these artifacts (Vaughan and Geddes, 2009).

The space syntax methodology allowed for a comparative analysis across different historic periods, investigating integration and

Table 1. Attractors, integration and choice values.

Attractor	Integration (axial) global	Integration local (r-2)	Choice (global)	Choice (r-2)	Ranking
Pantheon	0.84	3.01	270,866	259	1
Coliseum	0.99	2.67	938,950	147	2
Roman Forum	0.99	2.39	938,950	147	3
Palatine Hill	0.99	2.28	1,000,000	95	4
Piazza Navona	0.93	2.84	895,919	173	5
Basilica di Santa Maria Maggiore	0.97	3.45	1,000,000	466	6
Trevi Fountain	0.81	2.07	262,000	19	7
Museo Nazionale di Castel Sant' Angelo	0.85	2.28	373,125	41	8
Domus Aurea	0.72	1.53	18,458	6	9
Palazzo Doria Pamphilj	0.99	4.04	557,841	1,390	10
Basilica di San Clemente	0.74	3.14	65,105	36	13
Basilica di San Giovanni in Laterano	0.83	2.87	239,063	380	14
Piazza Venezia	0.99	4.08	557,841	1,390	15
Monumento a Vittorio Emanuele II	0.99	2.57	557,841	1,390	16
Terme di Caracalla	0.79	1.64	363,411	51	17
Piazza del Poppolo	0.99	3.28	959,349	1,390	18
San Pietro in Vincoli	0.63	1.24	18,458	4	19
Santa Maria della Vittoria	0.88	3.96	176,988	253	20
Church of St Louis the French	0.85	2.26	14,508	17	21
Le Domus Romane di Palazzo Valentini	0.98	2.16	33,296	59	22
Chiesa di Sant' Ignazio di Loyola	0.89	2.39	37,821	26	23
Torre Argentina Cat Sanctuary	0.87	3.02	270,866	259	24
Santa Maria in Trastevere	0.75	2.68	580,019	399	26
Quirinale Palace	0.88	2.30	176,988	253	28
Villa Farnesina	0.63	2.01	324,428	40	30
Mercati di Traiano	0.98	2.71	35,713	4	31
Palazzo Barberini	0.86	2.55	950,000	466	34
Piazza del Campidoglio	0.77	2.20	56,574	26	35
Spanish steps	0.77	3.38	950,000	343	36
Chiesa di Santa Maria del Popolo	0.99	3.23	557,841	1,390	37
Basilica di Santa Maria degli Angeli e dei Martiri	0,86	3.09	69,587	226	38
Museo Nazionale Romano – Palazzo Altemps	0.84	3.32	18,774	26	39
Campo de' Fiori	0.76	2.67	81,106	26	43
Basilica di Santa Prassede	0.81	2.64	12,755	14	45
Ponte Sant Angelo	0.85	3.05	373,125	23	46
Chiesa del Gesu	0.87	2.72	167,005	80	47
Santa Maria Sopra Minerva	0.79	1.94	36,926	25	48
Basilica di Sant Andrea della Valle	0.85	2.68	325,432	38	49
Fontana dei Quatro fiumi	0.78	2.42	35,703	15	50
Teatro di Marcello	0.82	1.98	473,285	26	54
Scala Santa	0.76	2.56	9,744	22	55
Terrazza del Pincio	0.77	1.61	8,862	4	57
Arco di Constantino	0.96	2.46	938,950	95	58
Santa Maria in Aracoeli	0.79	2.13	29,658	12	59
Santa Cecilia in Trastevere	0,67	2.25	89,375	54	60

Table 1. (*Continued*)

Attractor	Integration (axial) global	Integration local (r-2)	Choice (global)	Choice (r-2)	Ranking
Villa Medici – Academia di Francia a Roma	0.93	2.23	29,024	24	62
Chiesa di Sant Agnese in Agone	0.81	2.65	91,682	37	63
National Roman Museum – The Baths of Diocletian	0.80	3.31	64,807	26	66
Stadio di Domiziano	0.92	2.57	89,161	173	67
Cimitero Accatolico per Stranieri	0.65	1.57	16,068	29	68
Basilica di Santa Croce in Gerusalemme	0.75	2.79	39,531	118	70
Priorato dei Cavalieri di Malta	0.58	2.33	25,631	52	71
Forum of Augustus	0.98	1.57	11,903	12	72
Colonna Traianna	0.80	2.06	35,713	15	73
Foro di Cesare	0.99	2.15	920,607	147	74
National museum of Palazzo venezia	0.86	2.25	93,981	47	75
Buco della serratura	0.58	2.33	45,519	52	76
Piramide cestia	0.70	2.22	42,879	12	79
Piazzale Garibaldi	0.33	1.76	39,200	4	80
Chiesa di Sant Ivo alla Sapienza	0.85	2.75	136,739	60	82
Basilica di San Agostino	0.87	3.62	895,919	58	83
Fontana del Acqua Paola	0.39	2.04	196,667	10	84
Roma dal Cielo Terrazza delle quadrighe	0.73	2.37	33,486	15	86
San Carlo alle Quattro Fontane	0.97	5.21	176,988	466	87
Isola Tiberina	0.82	2.16	219,407	25	88
Piazza di Santa Maria in Trastevere	0.75	2.43	580,019	399	89
Circus Maximus	0.96	2.40	342,677	38	90
Arco di Tito	0.73	1.80	74,377	20	91
Bocca della Verita	0.89	2.41	473,285	38	93
Piazza della Rotonda	0.84	2.20	270,866	259	94
Museo Ebraico di Roma	0.85	2.45	218,497	26	95
Quatro Coronati	0.74	2.37	17,421	10	96
Basilica di Sant Andrea delle Fratte	0.92	2.25	27,048	8	97
case Romane del celio	0.61	1.89	16,634	6	100

choice values (Omer and Goldblatt, 2016). The angular segment analyses were generated with DepthmapX software. An angular segment integration analysis with high metrical value (radius n) and low metrical value (radius 2000 m) indicates the to-movement potential in the urban system (Figure 3), whereas the angular choice analysis with radius n and 2000 m reveals the potential through-movement on city and local scale in the studied urban area (see Figure 4) (Yamu *et al.*, 2021).

Following the diachronic space syntax analysis, an investigation is performed of cultural heritage attractors on the contemporary street network correlated with space syntax analyses on (t3). Studies that investigate the number of buildings with retail activity suggest using buffer areas to identify the retail activity linked to each street (Omer and Goldblatt, 2016). Since the presence of cultural heritage attractors is less common compared to retail activity, we perform a slightly modified version to measure the correlation of cultural

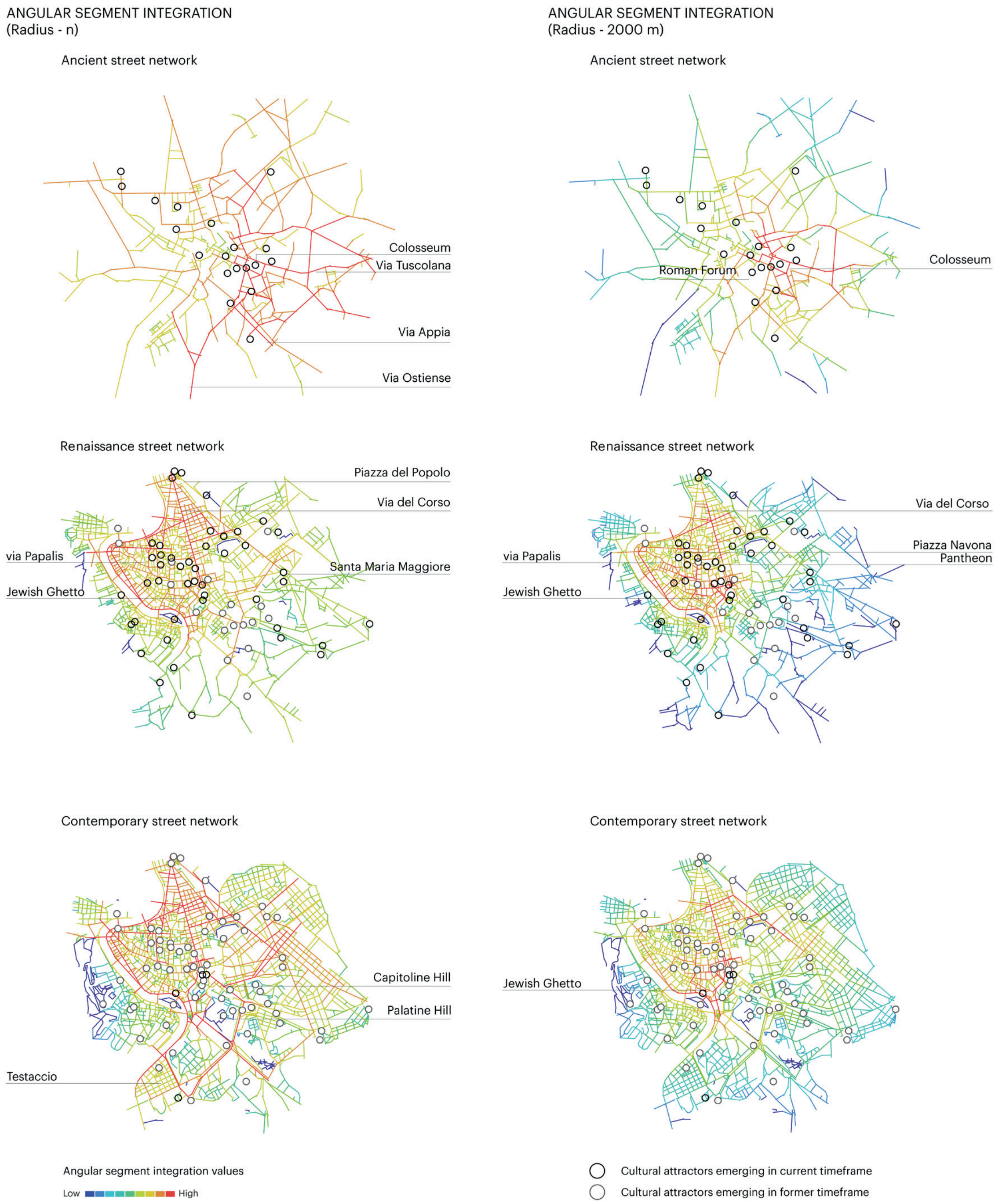

Figure 3. Diachronic angular segment integration and cultural heritage attractors in Rome

heritage attractors, integration and choice values. The average street integration with a maximum topological total depth of two steps is correlated to cultural heritage attractors and categorized according to their popularity (van Nes and Yamu, 2021). The correlation with choice values, on the other hand, is measured by linking only the highest through-movement street to the cultural heritage attractors categorized based on popularity (see Figure 5).

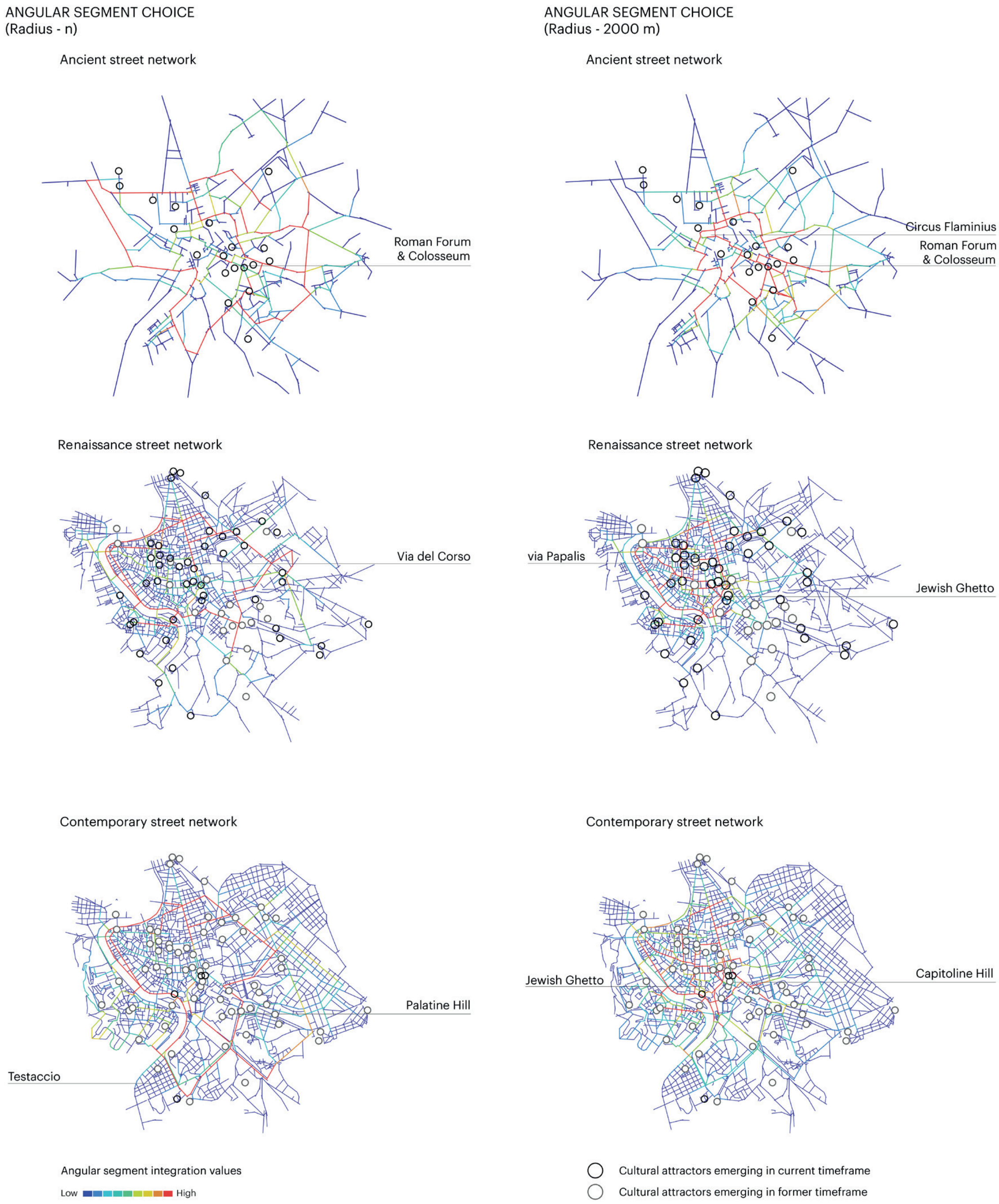

Figure 4. Diachronic angular segment choice and cultural heritage attractors in Rome.

Results from the macro-spatial analysis

An initial comparison of the analysis from different periods reveals heterogeneous clusters of high angular integration and choice values, depending on each timeframe. In the case of through-movement, the analysis varies from a local to a global scale. Historical reference to the topology and the former use of contemporary cultural attractors can be obtained by examining the highest values in the maps and cross-referencing through historical documentation.

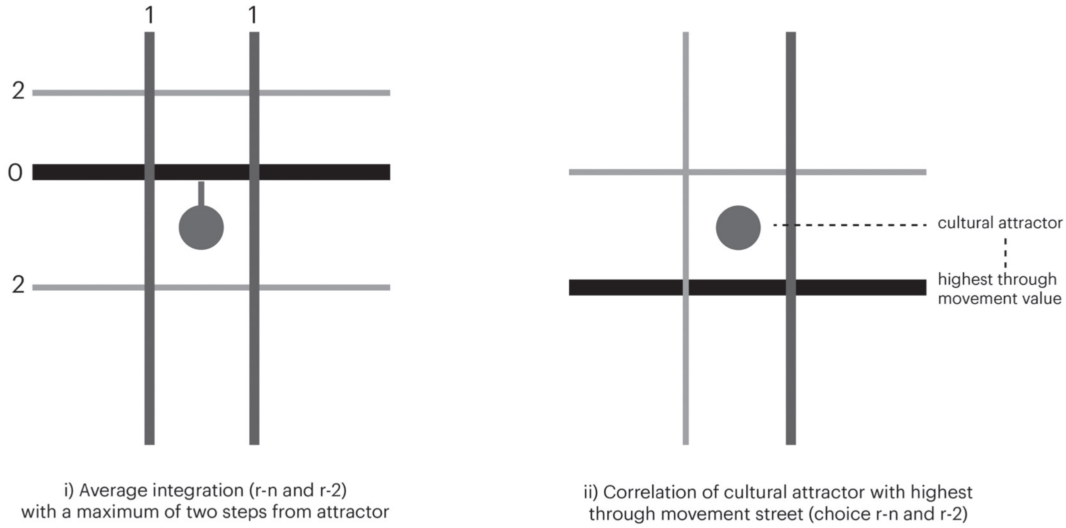

Figure 5. Method of correlation between cultural heritage attractors and i) average axial integration with two steps from attractor and ii) association with highest through movement.

In timeframe (t1), high integration values and local through-movement (r 2000 m) are concentrated around the Roman Forum and the Colosseum. This is supported by historic records representing this area as the heart of public life, economic and political events during Roman times (Taylor *et al*., 2017). During timeframe (t2), a change in the highest to-movement potentials occurs. The area of the Colosseum and the Roman Forum is no longer in first place when measuring high integration values. Instead, the highest values are shown in the northern area of the centre of western Christianity during the Papal State (Aureli *et al*., 2010). Historical documentation on the Baroque replanning of Rome confirms a shift towards the area of the Trident, an area consisting of three streets (Via Lata, today via del Corso; via di Ripetta; and via del Babuino) (Aureli *et al*., 2010; Taylor *et al*., 2017). These interventions were part of the popes' intentions to connect the seven churches of Rome, later adding obelisks to highlight the visual connections between pilgrim routes (Frommel, 1986; Çelik *et al*., 1994).

The location of the basilicas and the obelisks poses a question for the principles of natural movement. According to the natural movement theory, attractors follow configuration. In the case of the basilicas, the street axes were planned according to the location of the religious buildings (configuration followed attractors). Based on the notion of natural movement and its applications in cultural attractors, we revisit the initial framework adding the notion of "movement culture" (Arbara, 2022), influenced by the concept of movement economy. Once an initial link is established between configuration, movement, and attraction, attractors may intensify street evolution and have a multiplier effect on it.

Therefore, in the context of cultural attractors, seemingly 'strong' heritage artifacts can, over time, affect the theory of natural movement in two aspects. First, urban expansion can follow important attractors, creating new street spaces to better link them with the existing fabric. Secondly, when the attractiveness of the historic artifacts becomes unique, the spatial configuration of the street and road network plays a secondary role regarding the tourists' to-movement. Thus, the spatial configuration is of greatest importance for the through-movement between these important artifacts.

Likewise, in timeframe (t2), the local choice analysis (radius 2000 m) presents interesting findings as the highest choice streets overlap with the route known as via Papalis (Figure 4). This street was " . . . the only Roman street that had a specific name and . . . was one of the most desirable and prestigious streets on which to live and have a business" (Cafà, 2010, p. 436; see also Taylor *et al*., 2017). It was also known as "the street of the pope" (Cafà, 2010, p. 436). At the same time, it was the "most effective and rapid route that connected the principal sites of secular and religious power in Rome", including hubs and commercial nodes such as Piazza Navona (Cafà, 2010, p. 436).

The spatial configuration of the street network in (t3) emerges after Rome became the capital of the Kingdom of Italy. Integration varies between high and low metrical values. Global integration values surround the part of the historic urban area such as the Capitoline Hill and the Palatine Hill, which contain important cultural attractors, forming a cluster between the street along the Tiber River, the Palatine Hill and the area of Santa Maria Maggiore. High global integration values also expand towards the southern part to the Testaccio neighbourhood, an area urbanized after 1871, indicating the city's expansion and the formation of new urban areas.

On the other hand, local integration values in the contemporary urban area show high values in the more walkable historic urban area of the Piazza Navona, the Pantheon, the Capitol square, the Castel Sant'Angelo and the Jewish quarter. The Jewish quarter is amongst the areas with the shortest street segments and small-scale urban blocks. This area, established in 1554 as a walled and gated quarter, hosted nearly 3,000 inhabitants at that time (Taylor *et al*., 2017).

The popularity of attractors today and spatial configuration

When comparing TripAdvisor's ranking of heritage attractors (y) to the integration and choice values of the linked streets (x), we obtain the following results (see Figure 6). First, Pearson's correlation revealed a moderate negative correlation for the axial global integration r = -0.34 and the low p value (0.0012) indicates strong evidence against the null hypothesis. The axial local integration showed lower correlation values (r = -0.21) and a higher p value (0.036) showing that the overall spatial system might have a stronger impact on the popularity of heritage attractors, rather than the local one. This result seems reasonable, given that heritage attractors perform as places that attract users aside from the local area. Secondly, a correlation with the global (r–n) and local (r-2) choice values revealed moderate correlations of r = -0.36 and r= - 0.33 respectively. Slightly higher numbers of correlation and lower p values are presented for the global choice compared to the local scale. The next part reveals in detail the micro-spatial parameters which may be involved in influencing culture-led movement in historic urban areas.

Micro-spatial variables

Figure 7 shows the map of the three main routes between the Pantheon and the Trevi Fountain. These routes are primarily pedestrianized. Route 2 and a part of route 3 are equipped with signposts with directions towards the Trevi Fountain and the Pantheon. All three routes are broken up and are not highlighted in the angular choice analyses with a low metrical radius. Therefore, additional micro-spatial configurative analysis tools are needed to reveal this local area in detail. The micro-scale method consists in analysing the spatial features identified in the 1960s (Jacobs, 1961; Gehl, 2001) with the aim of operationalizing these into quantifiable sets of variables (van Nes and López, 2010; Cerrone *et al*., 2021).

The two attraction points, located less than 10 minutes walking time apart, are often visited in sequence, creating specific culture-led itineraries within the historic city. This trajectory is presently a well-known culture-led movement route in Rome. However, neither a spatial nor a clear historical connection between these two artifacts existed until very recently. On the one hand, the Trevi Fountain

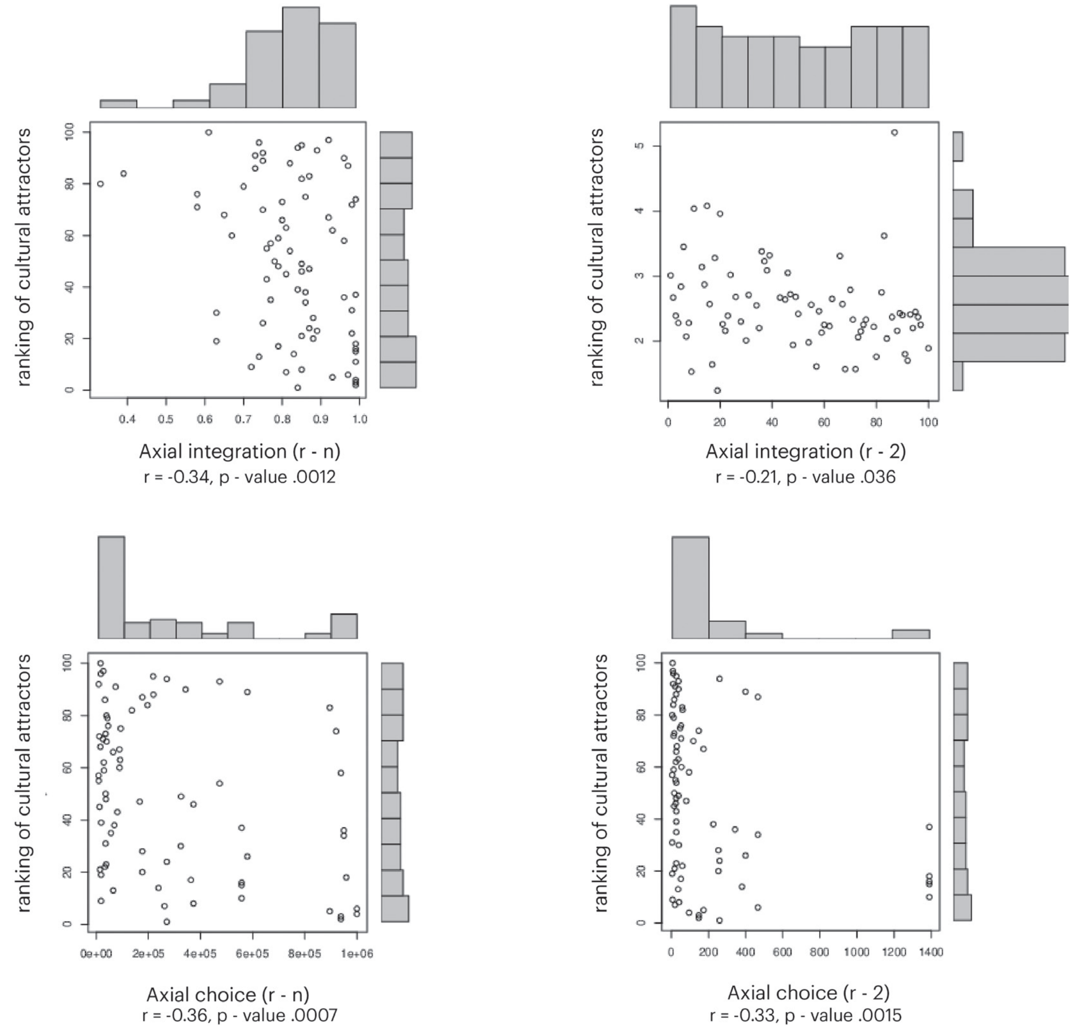

Figure 6. Correlation between the ranking of heritage attractors and axial integration and choice values for (t1).

is a late-Baroque monument constructed in 1762. On the other hand, the Pantheon is a former Roman temple, completed around 126–128 AD during the reign of Emperor Hadrian. Likewise, these areas belong to different administrative districts, Colonna and Trevi, spatially divided by the important retail corridor of Via del Corso.

Overlaying Nolli's map of public-private spaces and built forms on the contemporary urban fabric reveals minor changes in the urban form (Figure 8). Thus, a reading through circulation space becomes even more relevant in historic areas that have seen minimal morphological changes. Yet the notion of urban space, particularly the human activity of the street space, has shifted drastically, creating pedestrian-intensive areas with the presence of cultural and historical poles of attraction.

The built environment features that encourage pedestrian movement across one street space when visiting cultural attractors are selected and presented here. This research identified four micro-spatial variables or local-scale urban design principles, based on previous empirical and methodological research (Boarnet, 2001; van Nes and López, 2010; Gil *et al*., 2012). These are the density of entrances, the degree of intervisibility, street constitutedness, and the topological

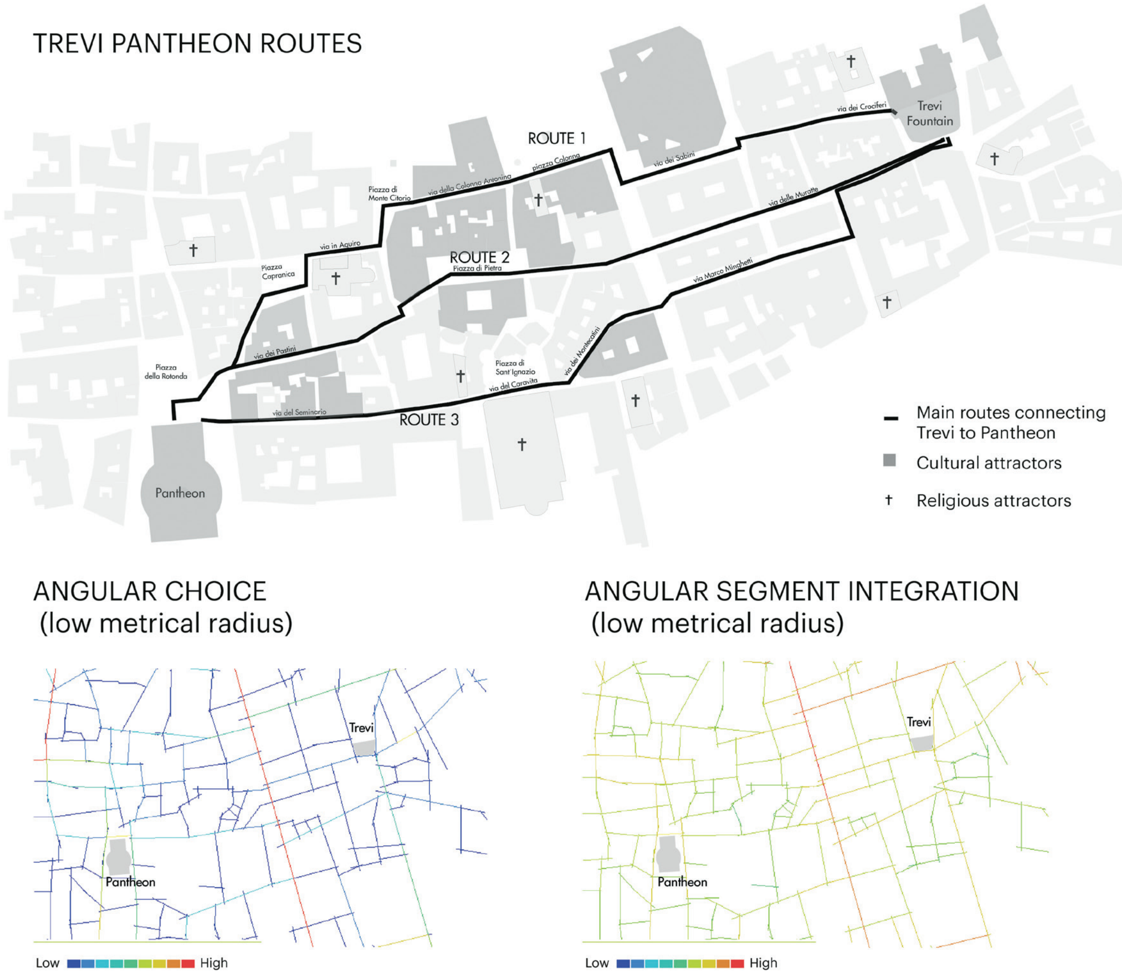

Figure 7. The three routes between the Trevi Fountain and Pantheon (upper) with space syntax analyses (lower).

depth between private and public space. With street constitutedness the degree of permeability of the buildings is understood (van Nes and López, 2007). Figure 9 shows different levels of built environment features three street segments of the studied area.

During a research project on space and crime, van Nes and López (2010) developed a set of urban micro-scale tools for quantifying the spatial relationship between public and private space in streets and roads. These tools turned out to be useful for indicating vital street life (van Nes and López, 2013; de Rooij and van Nes, 2015), perceived safety (Rønneberg Nordhov *et al*., 2019), street safety for women (Miranda and van Nes, 2020), walkability (de Koning and van Nes, 2019) and the location of micro-scale businesses (van Nes and López, 2013). The urban micro-scale tools quantify or visualize the spatial relationship between private and public space. The elementary principle is that a building façade must have a door with a window next to it on the ground floor level for it to be considered a spatial connection. Likewise, the function of the ground floor must be active, such as a dwelling, a working place, amenities, a shop or a café.

Density and type of entrances

The entrances were categorized into i) cafés-restaurants, ii) shops, and iii) other entrances (mostly building entrances, hotel, and service

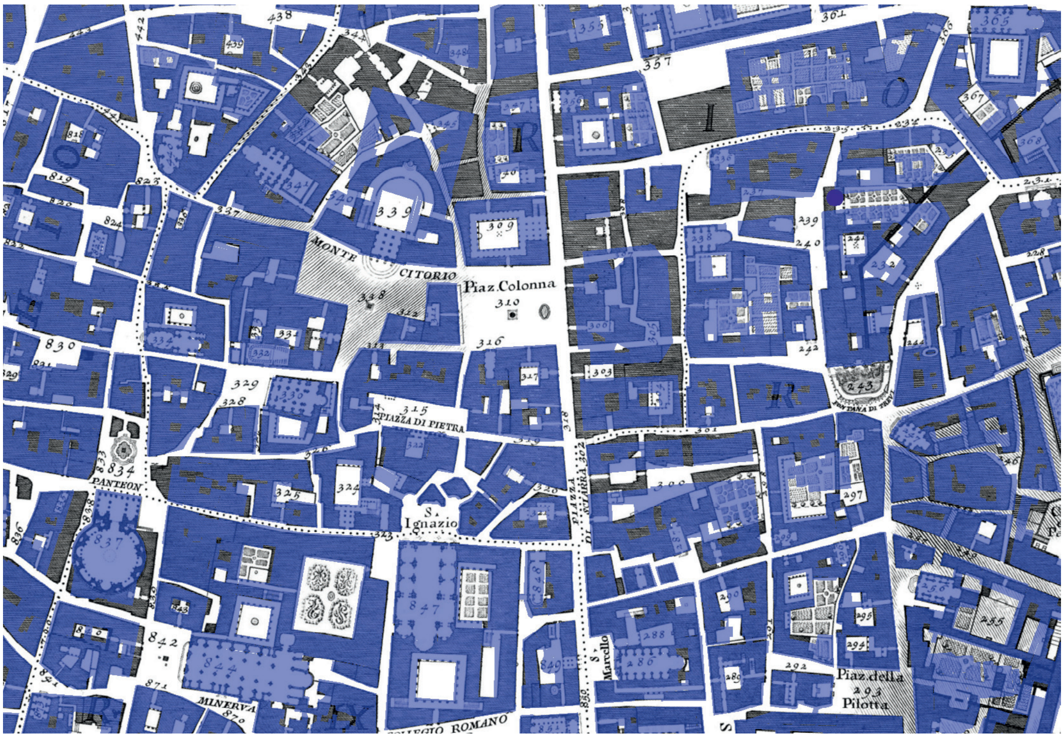

Figure 8. Minor changes in urban form from the eighteenth century to today (black: 1748 Nolli map; blue: contemporary urban fabric) (source: https://web.stanford.edu/group/spatialhistory/nolli/).

Figure 9. Left: route 2, high density of entrances, intervisibility and constitutedness. Centre: route 3, high intervisibility, low density of entrances. Right: side street with low intervisibility and density, unconstituted.

entrances). When the adjacent building has a passive function on the ground floor level, such as a storage space or parking garage, it is not counted as an entrance (van Nes and Yamu, 2021). Because entrances facing streets relate to the pedestrians' lived experience of the street (Jacobs, 1961; Gehl, 2001), multiple entrances of the same use (such as a café with multiple entrances) were all counted. The density of entrances was analysed on two bases. First, based on the high, medium, or low entrance density of each street segment and secondly, based on proximity to the two heritage attractors (radius – 150 m) (see Figure 10).

Street constitutedness

The street constitutedness measures the degree of permeability of the buildings to the street. In this paper, we use Shu's definition to differentiate between constituted and unconstituted streets, according to which a street is considered to be constituted if more than 75 per cent of the entrances of the adjacent dwellings have front doors directly facing the street (Shu, 2000). Unconstituted streets show a lower level of stationary activity of people, and crime levels are reportedly higher (van Nes and Yamu, 2021).

Intervisibility

The intervisibility analysis registers the way in which window and street entrances are positioned on the ground floor. A way of measuring intervisibility is to calculate the number of entrances that face each other across the street, compared to those that do not (van Nes and Yamu, 2021). In this study, streets were considered to have a high degree of intervisibility if more than 50 per cent of the entrances were facing each other. If not, the street was classified as having a low degree of intervisibility (see Figure 10). Windows and entrances located opposite to each other indicate more "eyes on the street" and a higher degree of safety and natural surveillance (van Nes and Yamu, 2021).

Topological depth

The topological depth measures the number of semi-private and semi-public spaces between the public and private spaces (van Nes and Yamu, 2021). For example, the topological depth is 1 if an entrance is directly connected to a street and there are no hybrid spaces between the entrance and the public space. In the case of shops, restaurants and other commercial activities, the topological depth is counted similarly; shop entrances facing the street directly have a topological depth of 1 (van Nes and López, 2007). The study area of Trevi–Pantheon, being part of the historic urban area of Rome, predominantly shows a high density of entrances directly connected to the street (see Figure 10).

Angular step depth from main attractors

Since the degree of attractiveness of important historical artifacts can overrun the spatial configuration of the street network, we conducted an experiment with the angular step depth analyses taken from the street facing the Pantheon and the Trevi Fountain at the same time. The three most-frequented routes between these artifacts are broken up and not supported by high values from the segment integration and the angular choice analyses, both on a city scale and a local scale.

In previous research analysing the degree of permeability of main routes to their adjacent neighbourhoods in 25 cities, van Nes (2021) conducted an angular step depth analysis from all main routes. As the results show, the more broken up the street network is inside the neighbourhoods, the poorer is the level of permeability between the main route and the neighbourhood. We applied this method on the main routes on a local scale. Here, all local main routes score well in the analyses (Figure 11).

Figure 11 shows the results of the angular step depth taken from the streets in front of the Pantheon and the Trevi Fountain. Only fragments from the three main routes are highlighted here. The reason is that all three main routes between these two famous attractors are very broken up. Therefore, signs are put up at certain points to direct the flow of tourists to these two urban artifacts.

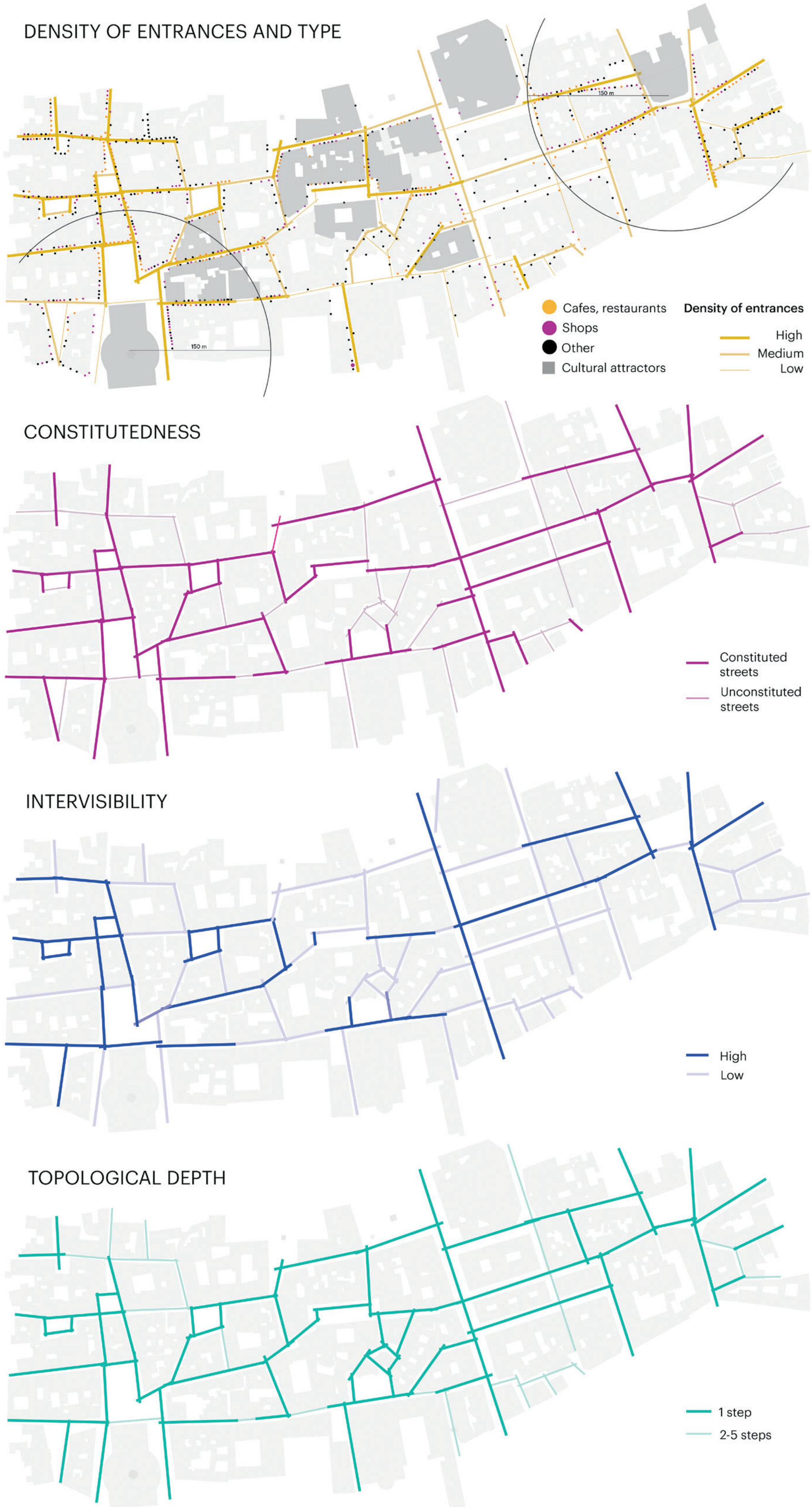

Figure 10. Micro-spatial parameters: density of entrances and type, intervisibility, constitutedness, topological depth.

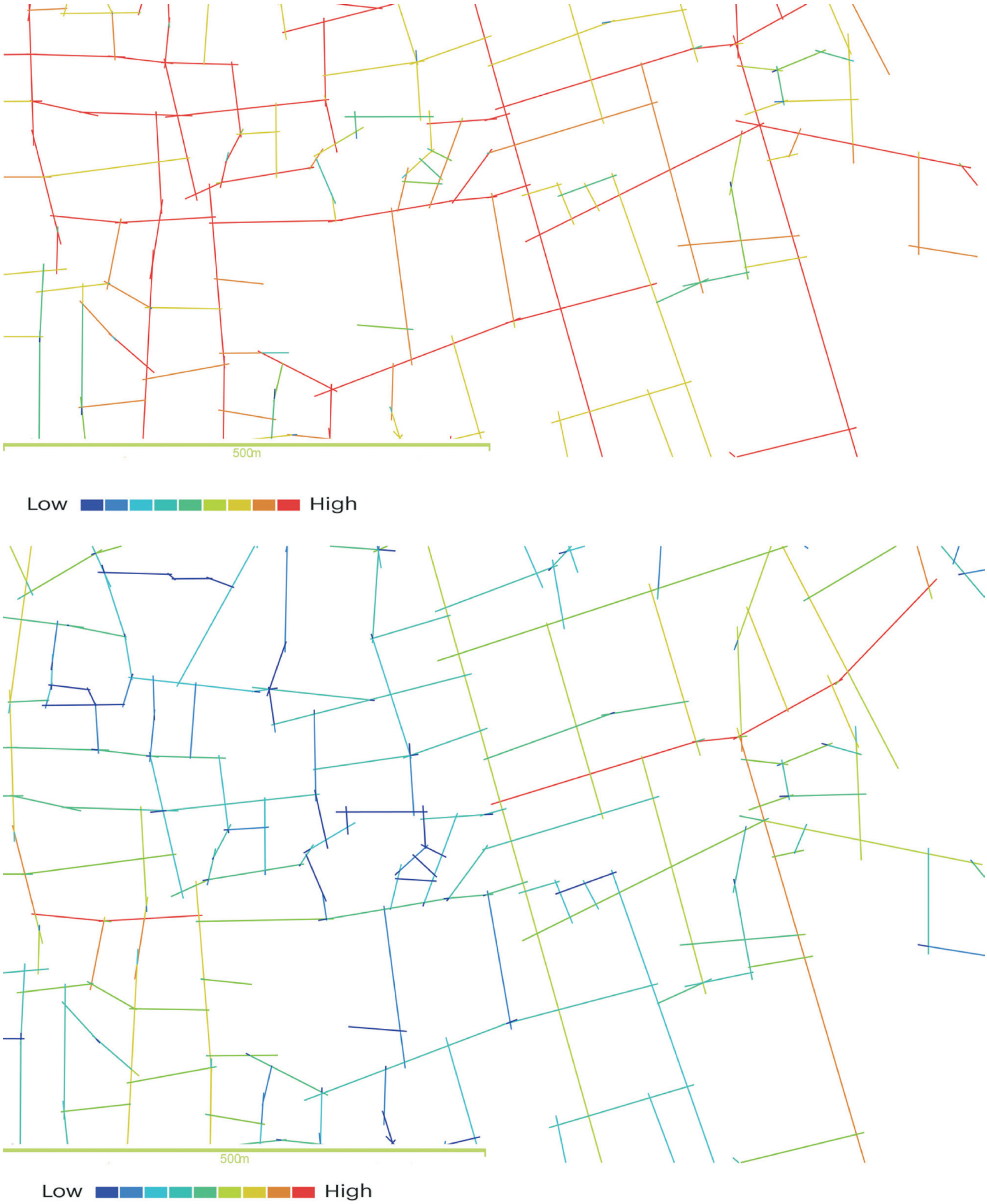

Figure 11. Left: angular step depth taken from the main pedestrian-based streets in Rome. Right: angular step depth analyses taken from the Trevi Fountain and the Pantheon.

Results of the micro-spatial variables

Previous studies on the Trevi–Pantheon routes indicate that Route 2 is selected by visitors, showing the highest intensity of movement (Porfyriou, 2010). This observation aligns with the results of the micro-spatial analysis performed in this research (see Table 2). Route 2 shows the highest density of entrances, both close to the attractors, and throughout the route, and performed higher on intervisibility measures and constitutedness. Its street typology is merely pedestrian compared to Route 1 and Route 3, allowing vehicle access, and is also the shortest path. Cultural attractors act as multipliers of commercial and leisure activities in all three routes, as the highest density of entrances is observed in the surrounding area of 150 m.

The macro-scale level analyses showed that high values on the spatial integration and choice were present in the location of the important historic artifacts at the time they were implemented. However, on a micro scale level, the movement observations in a current context are related to the shortest distance where the streets are constituted by building entrances. This raises the question of whether the spatial variables that provide insights on culture-led movement may vary depending on the scale of analysis, with the micro spatial variables being the most relevant method to investigate this phenomenon in smaller urban areas.

Conclusion

To what extent does spatial configuration matter in relation to the location of important, strongly attractive for tourists, cultural or historic artifacts regarding human movement in the built environment? Certainly, spatial configuration matters at the time when these types of artifacts were constructed. Good correlations are shown also between the current most popular cultural attractors and the global integration of the contemporary street network. In some cases, city growth or urban transformation processes through time can affect the relative location of these artifacts. Research has shown that shops as attractors for human movement are easily affected by configurative changes of the street network and tend to relocate to the most central location (van Nes, 2021). However, strong cultural or historic artifacts cannot '*replace*' themselves according to spatial configurative changes.

Table 2. Results from the micro spatial analyses.

Micro spatial analyses	Route 1	Route 2	Route 3
Urban regeneration project	no	yes	no
Length of path (m)	643	610	640
Density of entrances	0.17	0.22	0.15
Number of entrances	115	132	98
Mean angular step depth from Trevi–Pantheon on segments of each route	2.30	2.13	1.69
Density of entrances R – 150 m from Trevi + Pantheon attractors	0.25	0.28	0.2
Intervisibility 80–100%	0%	0%	0%
Intervisibility 60–80%	21%	33%	23%
Intervisibility 40–60%	7%	0%	0%
Intervisibility 20–40%	38%	21%	26%
Intervisibility 0–20%	42%	46%	51%
Constituted	85%	97%	82%
Unconstituted	15%	3%	18%
1 topological step depth	100%	100%	88%
2–5 topological step depth	0%	0%	12%

The study of Rome shows that the location of strong cultural artifacts can distort the natural movement in cities in the way in which they function as strong movement attractors. If the artifacts are located in spatially segregated areas, the streets tend to be dominated by tourists, and the cafés and shops tend to orient their facilities towards tourists. On the contrary, if the artifacts are located in a spatially integrated area, then a variation of tourists as well as locals frequent the streets. These streets tend to have shops and cafés that serve both tourists and locals.

A diachronic and multi-scalar analysis provides insights into the use and positioning of artifacts in the past when they were an integral part of the city's activities. This research depends on the availability of reliable maps for each time period. The macro-micro analysis provided additional information on the connectivity of attractors and the potential route choices for tourists in the present context. In the case of the Trevi–Pantheon routes, various spatial micro-scale conditions and the implementation of street regeneration projects including signage are parameters which can be indicative to the route choice between important historic artifacts when the natural through-movement spatial potentials are weak.

Although this research investigated only one city, the theoretical and methodological framework used in this inquiry sets the basis for studies on spatial configuration in relation to cultural heritage attractors and natural movement theory. It is important to acknowledge the forces of strong cultural attractors on the one hand and the spatial configuration on various scale levels on the other, in order to understand movement flows through streets in the built environment.

As clear correlations in urban design are less likely to be identified, especially when investigating cultural related phenomena, further research is needed to verify the links across scales and the evolutionary patterns throughout time, and to validate the methods of applying natural movement theory related to cultural spaces and the location of artifacts. This will also re-evaluate the set of micro-spatial parameters according to case-specific characteristics. Such an expansion of case studies in other historic contexts would add empirical support and bridge the gaps between urban design practice, urban strategic planning, sustainable tourism management, and heritage studies.

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