Mapping Emotional Landscapes: Understanding the Interplay of Emotions and the Built Environment in Potenza, Italy

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Abstract. The emotional responses of individuals to the built environment is a central aspect in developing strategies for urban regeneration, in particular in the context of the pandemic and environmental crises. Emotional responses are not only integral to personal quality of life but also influence urban practices. Concepts aimed at fostering sustainable, inclusive, and vibrant urban areas, hinge upon fostering positive emotional experiences. Understanding how people perceive urban spaces is central to promoting active mobility and social interaction. This study focuses on two districts in Potenza, Italy, examining the distribution of emotional responses and identifying built environment factors that influence individuals' reactions. The study operates on the premise that built environment factors elicit distinct emotions, which, in turn, impact individuals' practices and motivations. Ultimately, this understanding informs strategies for urban regeneration, emphasizing diversity, density, proximity, sustainable mobility, and resilience.

Keywords: PPGIS · Emotional Response · Space Syntax · Place Syntax

1 Introduction

Individuals' emotional response to the built environment represents a central aspect to developing actions of urban regeneration in the context of the post-pandemic scenarios and the environmental crisis. Emotional response, defined as a set of interdependent reactions function of a state of arousal and of its evaluation, is relevant per se, as a component of life satisfaction and individual quality of life and as a factor mediating individual practices. As a result, it emerges as a central concern to the realization of urban concepts, including the 15-minutes city, aimed at constructing sustainable, resilient, inclusive, vital and just cities.

The article is the result of the joint work of the authors. In particular, Beniamino Murgante oversaw the conceptualisation and the supervision of the study and wrote the 'Introduction' and Discussion and Conclusion. Giovanni Mazzarelli oversaw data collection and data analysis. Alfonso Annunziata oversaw the methodology, data analysis and data visualization and wrote the 'Methodology' and 'Results' sections. Claudia Hedwig van der Laag oversaw the supervision and validation of the study and wrote the 'Literature Review'.

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These concepts, in fact, are based on criteria of density and diversity of functions, optimization of services provision and population density, incentivization of active mobility, integration of ecological infrastructures and urban structures, and resignification of urban spaces as places of sociality. In this perspective, positive emotional responses to the built environment can increase people's propensity to opt for active mobility solutions and to engage in recreational and social activities in urban spaces. As a result, the proposed study is focused on urban concepts based on criteria of density, diversity, proximity, sustainable mobility and investigates and is aimed at: i) understanding the distribution of individuals' emotional responses to urban spaces in two districts of the City of Potenza, in Italy; ii) identifying built environment configurational, structural and functional factors related to the distribution of emotional responses. The study is based on three premises: i) built environment factors elicit specific emotional responses; ii) emotional responses influence individuals' motivation and actions, including travel practices and intention to engage in recreational and social activities in urban spaces; iii) understanding relations among built environment factors, emotions and individual practices is relevant to the definition of actions of urban regeneration based on criteria of diversity, density, proximity, sustainable mobility and resilience. The article is articulated on six sections. After the introduction, Sect. 2 presents an analysis of the literature on basic emotions, emotions' impact on individual practices and on urban concept based on criteria of diversity, density, proximity and sustainable mobility. The methodology is described in Sect. 3 and Sects. 4 and 5 present and interpret the results of the analysis. Lastly, the conclusions section underlines the implications of the findings of the study and outlines its future development.

2 Literature Review

The analysis of the literature is focused on three aspects: i) definition of basic emotions and emotional response; ii) the influence of emotional response on individual practices, including travel practices; iii) urban concepts based on criteria of density, diversity, proximity and sustainable mobility. A fundamental definition of Emotional response is provided by Schachter and Singer [1]. Emotions are conceptualized as a reaction function of a state of arousal and of a cognition relevant to the perceived stimulus. The evaluation of a set of stimuli, resulting in alterations of a person's state, and influencing a reaction is central to the definition of emotion intrinsic to the component process model [2]. The cognitive evaluation of the significance of a person-environment interaction is also central to the definition of emotion proposed by Lazarus [3].

In urban studies, emotional response to built environment factors emerge as an aspect of life satisfaction and individual quality of life [4]. A conceptual model proposed by Mouratidis [5] identifies emotional responses, as a factor mediating the influence of the built environment on life satisfaction. Studies on pedestrians' satisfaction [6, 7], residential satisfaction [8–10], emotional response to environmental stimuli [11, 12] underline the influence of the experience of the built environment on individual practices, life satisfaction and quality of life. Regarding emotional responses, Mouratidis identifies contentment, pleasure, and fear as relevant emotional states [5]. Resch et al. [13] individuate contentment, sadness, fear, and anger/disgust as basic emotional states.

Birenboim and Weijs-Perrée et al. [11, 14], conceptualize emotional responses in terms of security, comfort, contentment, and frustration, elicited by situational variables and environmental factors. Emotional responses' influence on individuals' actions can represent a relevant factor for incentivizing active travel, and people's engagement in activities in urban spaces. Bornioli et al. [15] build on Russell's definition of affective state [16] to demonstrate the influence of individual's emotions elicited by the built environment on their propensity to walk. Gatersleben and Uzzell [17] observes the influence of affect on individual practices and intentions and, as a result, the relevance, to policies aimed at promoting sustainable mobility, of understanding factors influencing individuals' travel experience and the motivation of individuals' preference of specific travel modes. Similarly, Ferreira [18] demonstrated that perceived built environment qualities, including its spatial structure and social environment, can impact residents' walking practices and intentions, and that these effects are mediated by residents' emotional relation to the district. Lastly, De Vos et al. [19] underline the interdependence among perceived environmental qualities, pedestrians' satisfaction, propensity to walk and life satisfaction. The last aspect concerns the criteria informing urban models aimed at realizing sustainable, resilient, inclusive and just cities. Emerging urban questions, concerning spatial injustice, climate alterations, ecological fragility, result in models of social and spatial reorganization of cities focused on ensuring access to urban resources and services, participation, sustainable mobility, ecological resilience [20–24]. In this context, the 15-minutes city concept has emerged as a relevant model for reorganizing urban areas in the post-pandemic scenario [25, 26]. The 15-minutes city concept aims to ensure that basic amenities are located at a distance equivalent to a travel time of 15-minutes from one' residence, so as to reduce dependency on cars and promote mobility solutions based on public transit and active mobility. Antecedents of the 15-minutes city model, including the Neighbourhood Unit Concept (NUC) [27, 28], New Urbanism [29, 30], transit-oriented development (TOD) [31–34], and neo-traditionalist design [35, 36], also propose compact, mixed-use, and pedestrian-centered urban structures. As a result, the founding criteria of these models include proximity, density and diversity. More precisely, Density refers to the optimal number of residents required to sustain a variety of services, Proximity underlines the spatial closeness of services of general interest, and Diversity refers to the combination of distinct urban functions and identities, fostering social interactions and quality of life. Lastly, Density, diversity and proximity to amenities are identified as factors conducive to active travel and recreational activities in urban spaces [37–40], and as factors conducive to positive health outcomes [41–44]. As a consequence, this study builds on the concept of interdependence among macro-scale built environment factors, pedestrians' experience and propensity to opt for active travel, and investigates the correlation among individuals' emotional response to the built environment and macro-scale built environment properties of density, proximity, diversity and accessibility.

3 Methodology

The objective of the study is the assessment of the frequency of emotional responses across public spaces and of the correlation among emotional responses' distribution and macro- and meso-scale properties of the built environment. As a result, the methodology

integrates Public Participation GIS techniques, spatial analysis and statistical analysis, and is articulated on five stages: i) reconstruction of a spatial dataset related to the distribution of services of general interest; ii) formulation of a map-based survey and analysis of survey's results; iii) computation of indices of configurational properties; iv) computation of indices of access to points of interest related to specific categories of services of general interest and computation of a synthetic index of coverage of SGIs; v) categorization of spaces based on the prevalence of positive or negative perceptions and characterisation of the resulting types of public spaces.



Fig. 1. Selection of the Area of Study: The Ancient Core and the Poggio Tre Galli District in Potenza, Italy

3.1 Reconstruction of the Spatial Dataset

The analysis focuses on the City of Potenza, in Italy. In particular, the selected areas of study are the Ancient Core, a compact, dense district, presenting a spatial structure organised by the axis of Pretoria street, and a system of transversal streets, or *Quintane*, and the Poggio Tre Galli district, a modernist district presenting a coarser spatial structure organised by spaces designed for motorized mobility, green areas, and semi-private

spaces separating buildings from the urban space (Fig. 1). The analysis focuses on six categories of urban land uses: recreational services, retail activites, sustenance services, public general services, urban green areas and non-built areas. Information related to the distribution of points of interest included in the categories public general services, retail activities, recreational activities, and sustenance services ate retrieved from Google Maps database. Information related to urban green areas and non-built areas are retrieved from the Copernicus Urban Atlas service. Information related to urban services includes the number of reviews and the average users' rating. The segment map is derived from the Road Centre Line map of the City of Potenza, retrieved from the Open Street Map database. A four-step procedure is utilised for constructing the segment map: first, centre lines related to roads not suitable for pedestrian movement are eliminated, including geometries comprised in the categories Arterial, Trunk, bridleway, construction, cycleway, emergency, path, raceway, service, and track. Secondly, the road centre line map is validated by repairing topological errors, via the Road Network Cleaner function of the Space Syntax Toolkit (SST). The sub-sequent step is aimed at converting the edited road-centre line map into a segment map, via the Network Segmenter function of the SST. Lastly, the segment map is edited by eliminating sets of isolated segments. The centroids of the streets' segments intersecting the area of study are selected as units of analysis.

3.2 Formulation of a Map-Based Survey

A map-based survey is created and administered via the Maptionnaire tool. Maptionnaire is a Public Participation GIS tool. Public Participation GIS (PPGIS) tools are a crucial component of urban and regional planning, as they enable the integration of local information and preferences and expert input. Web-based tools enable asynchronous and distributed participation, overcoming the limitations of traditional participatory practices [45–47]. In particular, the utilization of the Maptionnaire tool for investigating people's perception of public spaces is relevant to studies in the fields of urban planning, geography, sociology, and environmental psychology. The Interdisciplinarity underlines the relevance of PPGIS tools for understanding the complex dynamics of the interactions among people and public spaces, involving the dimensions of accessibility, safety, attractiveness, and usability [45, 48–50]. The map-based survey structured for the present study is aimed at retrieving information on locations, across the selected areas of study, associated with specific positive emotions, including contentment, safety, comfort, and negative emotions, including fear, boredom and anger/disgust.

Spatial information related to individuals' experience of public spaces across the areas of study is formalised via geostatistical analysis tools. The spatial lag of the frequency of participants' answers, for each basic emotion is computed for each unit of analysis. The spatial lag is selected as the dependent variable in order to minimise errors resulting from answers' misplacement and to avoid sudden breaks in the answers' distribution.

3.3 Configurational Indicators

Step four consists in the definition and computation of a set of indicators of configurational properties. Configuration refers to the topological relations among elements within a spatial structure. More precisely, it denotes the specific organization of a spatial structure that manifest and perpetuate principles governing social interactions. The interdependence among spatial configurations and social practices is intrinsic to the concepts of movement economy and centrality, which elucidate how urban centers and sub-centers emerge from a process of mutual influences among the distribution of natural movement, location of economic activities, and the layout of the urban environment [20, 21, 51–53]. The study employs centrality metrics to evaluate the influence of the built environment on the intensity of pedestrian activity. Integration measures the distance from each starting point to any potential destination within the environment. It measures a spaces's relevance as a destination. Choice measures the probability that a space is located along the shortest route from each location to any other location within a spatial structure. Hence, it measures the through movement potential of a space, that is, its relevance as a movement space. Distance is quantified as the sum of angular deviation along a route (angular distance) [54]. The radius definition isolates spatial sub-structures around a starting point, enabling the assessment of configurational properties at micro-, meso-, and macro-scales. Moreover, measuring configurational properties at different scales facilitates understanding the impact of the Built Environment on various types of movement. In particular, radii ranging from 400 m to 3000 m are relevant for investigating how configuration influences pedestrian movement [55]. Moreover, Visibility Graph Analysis (VGA) is used to measure the properties of the visibility graph derived from the spatial layout of the areas of study. More precisely, VGA investigates the visibility relations among individual locations and the entire spatial layout [56]: the aim is understanding the interdependence among perception of space, movement and interaction. The metrics considered include visual integration, defined as the visual distance from each space to any other space, through vision, defined as the number of lines of visibility that intersect a location, visual control, computed, for each location, as the sum of the reciprocals of the number of locations visible from the adjoining cells and isovist compactness, measuring the regularity of the isovist polygon generated for each location [57]. Lastly, the structure of the areas of study is described in terms of Road Intersection density, as a measure of the permeability of the built environment [20, 21, 24, 58], openness and transversal dimension, as measure of the degree of enclosure of individual spaces [59] and Ground Surface Index [20, 21, 39, 60], measuring the local building density around each segment.

3.4 Access to Urban Services

The proximity of urban services to street segments is determined via the Attraction Reach (AR) function of the Place Syntax Tool. The Place Syntax tool is an open-source spatial analysis platform, developed by researchers from the KTH School of Architecture, Chalmers School of Architecture (SMoG), and Spacescape AB. PST integrates Space Syntax Theory into urban environment analysis. By incorporating points of interest defined by spatial coordinates and quantitative data, and the spatial layout defined by

street segments, the tool facilitates the evaluation of accessibility to specific locations. The AR function measures the proximity to the j-th segment of points of interest (POIs) of the i-th category of urban services. The proximity score for each service category is calculated based on the inverse ratio of the distance to the POIs from the segment, within a predetermined radius of 400 m, and is multiplied by a quality factor. The quality factor is computed as the product of the normalized count of reviews by the normalized users' average rating. To quantify urban service coverage, a composite index, the ISG, is introduced. It is calculated as the weighted average of the normalized AR metrics for each service category. The ISG index values range from 0 to 1, and indicate a gradient from limited access to SGIs (values tending to 0) to optimal access to SGIs (values tending to 1). The proposed metrics address limitations of existing measures of proximity and diversity by incorporating in the measurement of conditions of access, a diversity factor, formalised in terms of presence of destinations related to distinct types of SGI, a variety factor, in terms of presence of alternative destinations for each service category, an impedance factor, conceptualised in terms of distance of destinations from the origin point, and a quality factor, formalized in terms of number of reviews and users' average rating.

3.5 Categorization and Characterisation of Segments

An emotional score is computed as the difference between the spatial lag of the frequency of positive emotional responses and the spatial lag of the frequency of negative responses. The segments are then divided into five quintiles based on the values of the emotional score and three conditions are selected for exploratory statistical analysis: spaces presenting a prevalence of positive responses, spaces presenting a prevalence of negative responses and spaces presenting null emotional responses. Segments included in the selected categories are assessed based on significant deviation among average values of the original variables. The Average Chart function is used to assess the significance of the disparity between the mean value of the j-th variable for the i-th subset and the mean value calculated for the rest of the observations. Significance is determined by the p-value derived from the f-statistic obtained from a regression incorporating a binary variable set to 1 for observations included in the i-th subset and 0 for the unselected observations.

4 Results

The results of the survey reveal distributions of the emotional responses specific to each district: In the ancient core, positive emotional response are concentrated in the central section of the district. In particular, a significant cluster of positive responses is located in Mario Pagano square, and secondary clusters can be identified along Pretoria Street and Giacomo Matteotti square: Consequently, the distribution of individuals' emotional response reflects the symbolic, functional relevance of public spaces. In The Poggio Tre Galli district, less intense clusters can be identified along the central, longitudinal axis of the district, and particularly in Europa Unita Park and Costituzione Italiana Square. Vice versa, negative emotions, including fear, anger, boredom are concentrated in marginal/edge areas (Fig. 2).

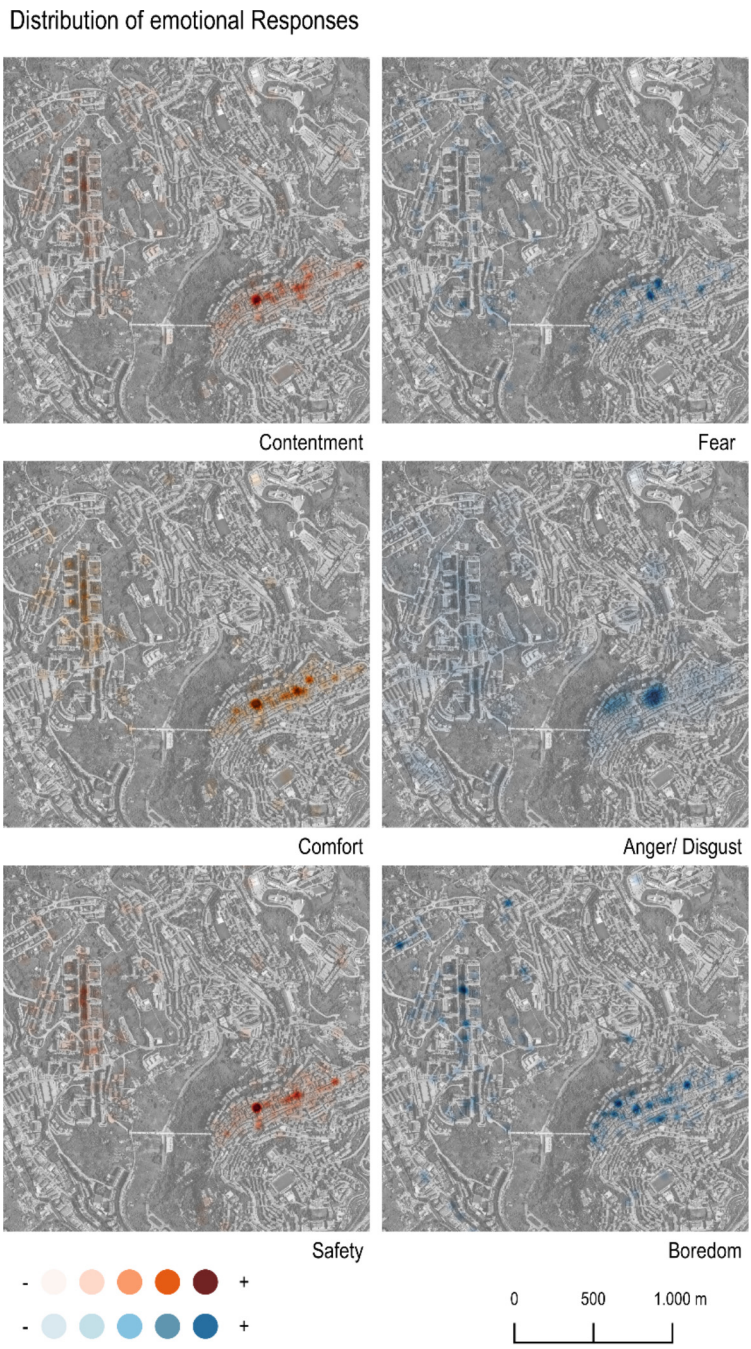


Fig. 2. Distribution of Emotional Responses.

As a result, a similar configuration emerges: A polycentric structure, and an elongated centre in the central section of the areas of study, related to positive emotional response, and a fragmented structure along the edges, related to negative responses (See Fig. 1). Regarding configurational and functional indicators, the ancient core's spatial structure is more permeable, compact and integrated compared to Poggio Tre Galli district (See Fig. 2). Moreover, the spatial layout of the ancient core presents superior levels of enclosure and of street alignment continuity. Angular Integration values underline the emergence of an eccentric core of spaces integrated at the local and macro-scale in the ancient core and a transversal spatial sequence, along Anzio Street, in the Poggio Tre Galli district. The gradient of angular choice values reveals the emergence of Pretoria Street as a central space at the local scale and of Anzio Street at the macro-scale.

Regarding visibility relations, A discontinuous sequence of spaces, along Pretoria street, can be identified in the ancient core, presenting superior levels of integration and isovist regularity. In the Poggio Tre Galli district, a continuous sequence of spaces, along Adriatico street presents similar conditions of visual integration and isovist regularity. Lastly, optimal levels of access to services, measured by the IGS indicator, are observed in the central core of the Ancient District. Inferior levels of access to SGIs are observed in the Poggio Tre Galli district, and result in a polycentric structure, constituted by a central core of spaces presenting adequate levels of service coverage, at the intersection among Anzio Street and the longitudinal axis comprising Europa Unita Park and Unità d'Italia street, and secondary clusters, presenting moderate levels of access to SGIs, along the edge of the district, in particular along Ancona street.

The exploratory analysis of the sub-set of spaces in the last quintile of the emotional score (ES < -0.33) underline significant configurational and functional properties of spaces presenting a prevalence of negative responses. Spaces eliciting negative emotions, in fact, present inferior conditions of permeability, density, and enclosure, indicated by values of the metrics Road Intersection density and Ground Surface Index minor than the average values of the non-selected observations, and by values of openness and transversal dimension above the mean computed for non-selected observations. Moreover, spaces eliciting negative emotions present inferior values of integration, inferior levels of access to general public services, recreational activities, retail activities and sustenance services, and levels of proximity to non-built areas above the mean of non-selected spaces (See Table 1).

Similar conditions are observed in spaces presenting no emotional responses: values of the DRI and GSI metrics, of integration at the meso-and macro-scale and of centrality at the micro-meso- and macro-scale are inferior to the mean computed for non-selected segments. Similarly, inferior levels of access to sustenance services, retail activities and recreational activities are observed in spaces presenting null emotional responses frequency. Consequently, values computed for the ISG are inferior to the mean calculated for non-selected segments. Vice versa, openness, transversal dimension and conditions of proximity to non-built areas are above the mean computed for non-selected spaces (Fig. 3 and Table 1).

Lastly, spaces presenting null emotional response present a more regular street front alignment, compared to segments eliciting participants' emotional response. Lastly, spaces presenting a prevalence of positive responses (ES > 1.78) are more compact

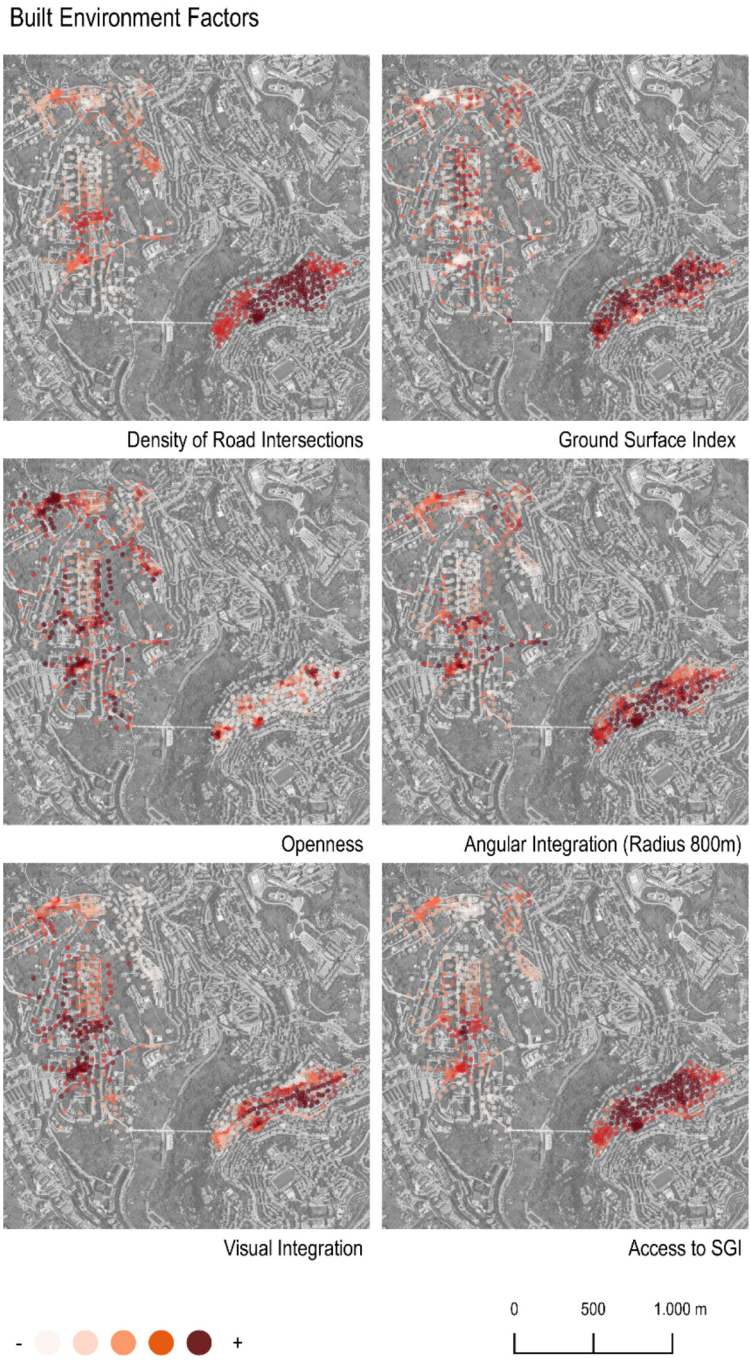


Fig. 3. Distribution of values of metrics of relevant built environment factors

(GSI above the mean of non-selected spaces), permeable, more integrated, in terms of visual relations and characterised by more regular isovists (Table 1).

Moreover, levels of angular integration at the micro and meso-scale (at radius 800 m and 1600 m), centrality at radius 800 m and levels of access to general public services, sustenance services, retail activities and recreational activities, and the composite indicator of access to SGIs present average values above the mean computed for non selected spaces.

Table 1. Results of the Exploratory Analysis of alternative types of spaces

		Negative Response	Positive Response	Null Response
VARIABLE	VALUE	COEF	COEF	COEF
DRI800	Constant	70.225	62.058	68.147
	Deviation	−14.754	26.988	−16.448
GSI	Constant	0.285	0.211	0.272
	Deviation	−0.120	0.256	−0.211
V_INT	Constant	0.521	0.488	
	Deviation	−0.059	0.112	
ME_DE	Constant	0.739	0.718	
	Deviation	−0.039	0.071	
REL_ENT	Constant	0.630	0.603	
	Deviation	−0.049	0.090	
IS_COM	Constant		0.794	
	Deviation		0.037	
AI800	Constant	103.622	99.384	
	Deviation	−6.951	14.777	
AI1600	Constant		221.631	228.190
	Deviation		19.702	−47.611
AI2000	Constant			299.431
	Deviation			−65.010
AI10000	Constant			792.687
	Deviation			−52.477
AC800	Constant		0.095	0.107
	Deviation		0.044	−0.050
AC1600	Constant			0.114
	Deviation			−0.063

(*continued*)

Table 1. (*continued*)

		Negative Response	Positive Response	Null Response
AC2000	Constant	0.081		0.091
	Deviation	0.035		−0.050
AR4GEN	Constant	0.336	0.265	
	Deviation	−0.130	0.237	
AR4RET	Constant	0.262	0.170	0.239
	Deviation	−0.160	0.308	−0.178
AR4GRO	Constant	0.204	0.175	0.201
	Deviation	−0.063	0.082	−0.166
AR4REC	Constant	0.293	0.202	0.272
	Deviation	−0.164	0.301	−0.209
AR4UGA			0.195	
			−0.049	
AR4NBL	Constant	0.162	0.225	0.177
	Deviation	0.141	−0.178	0.235
ISG	Constant	0.241	0.179	0.224
	Deviation	−0.118	0.197	−0.125
ST_AL	Constant	19.074		22.455
	Deviation	10.460		−20.462
W	Constant	30.918	33.991	31.057
	Deviation	4.423	−11.387	13.073
OPEN	Constant	0.708	0.754	0.713
	Deviation	0.073	−0.162	0.168

Interestingly, levels of access to urban green areas and non-built areas are inferior to mean values observed for non-selected spaces. Lastly, spaces eliciting positive emotions present superior levels of enclosure, indicated by average values of the transversal section and openness metrics inferior to the mean computed for non-selected spaces.

5 Discussion and Conclusion

The results conduct to distinct considerations: first, the selected areas of study reflect distint urban paradigms, resulting in specific configurations. The modernist urban development of Poggio Tre Galli presents a spatial structure designed to facilitate motorized transport, resulting in a coarser, sparser and more segregated configuration, defined by open spaces and green areas, and presenting modest levels of access to services.

Vice versa, The ancient core spatial structure is more compact, dense, permeable and integrated, defining enclosed spaces and presenting optimal levels of access to public services, sustenance services, retail activities and recreational activities. Building on previous studies of Italian cities' levels of compliance to the 15-minutes city concept [20, 21], the findings confirm the positive relation among levels of access to services and conditions of streets' enclosure, integration, permeability and compactness.

The distinct spatial configuration results in significant diversity in terms of individuals' perceptions. Observed Emotional responses are more numerous in the ancient core, and determine a positive emotional score, above the mean value computed for the Poggio Tre Galli district. A second consideration regards the potential relation among macro-scale built environment factors and emotional response. More precisely, the results suggest that spatial and visual integration, enclosure, permeability, compactness, and density and diversity of urban functions are factors conducive to positive emotions and perceptions of the built environment. The relevance of the study relies on its contribution to the understanding of the interactions among built environment, individual emotions, and individual and social practices. The study, in fact, underlines the positive potential impact of specific meso- and macro-scale built environment factors on individuals' emotions. The findings are relevant to the development of strategies of urban regeneration: given the importance of emotions per se and as factors influencing modifications in individuals' practices, the study identifies enclosure, permeability, compactness, and density and diversity of urban functions as significant criteria for developing sustainable, inclusive and resilient cities.

Disclosure of Interests. The authors have no competing interests.

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