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A human-scaled GIS: measuring and visualizing social interaction in Barcelona's *Superilles*

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ABSTRACT

Social interaction is a key component of urban sustainability, but its spatial measurement is difficult using existing off-site GIS data. This paper reports on a new method of measuring social interaction using a combination of mobile technology and parametric software, which was tested on two of Barcelona's new semi-pedestrian *superilles*. The research is introduced within a theoretical framework for *social interaction and cohesion* adapted from a broader index of sustainability. It shows how on-site data collection can be used to measure the capacity of urban spaces to support social interaction. It is argued that the combination of mobile technologies, GIS data, and predetermined indicators of the capacity of spaces to support positive human experiences offers an important complement to more traditional methods of recording and measuring the qualities of urban spaces.

KEYWORDS

Streets; GIS; social interaction; Barcelona *superilles*

Introduction

Digital information is changing urban design, both in the way people experience cities and how designers measure the physical and social qualities of urban spaces (McCullough 2013). While people want walkability, livability, and social interaction in dense and diverse downtown locations, the dominance of cars has left many urban spaces unhealthy places to live (Urry 2007).

Small-scale spatial understanding of downtown social interaction, while well studied in behavioral science, sociology, and urban psychology, has been challenging to measure geospatially for design professionals. As a temporal quality of human processes, it is often excluded from urban data collection, which tends to favor either fixed forms or non-spatial analyses (Lavirov 2015). New ways of integrating the social process data via mobile computing (Ratti and Claudel 2015) offer potential methods of including the post-occupancy approaches of Gehl (Gehl and Svarre 2013), Cooper Marcus and Francis (1998), and others.

Barcelona's semi-pedestrianized *superilles* provide a valuable new context in which to study social interaction in urban spaces and to test new methods of measuring the human qualities of urban spaces. The research method described used on-site mobile technology

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integrated with GIS and digital visualization to measure relationships between physical environmental factors and social interaction.

The method is significant because social interaction plays a key role in urban theory, including the "walkability" notions of Gehl and others, for example, but no method of this scale or reliability is currently available to measure social interaction in urban environments. The work presented examined qualities experienced at street level in two downtown *superilles*, together with more traditional urban spaces suggested by the City for baseline comparison (Agencia 2016) (Figure 1).

Cultural context

In Catalan culture, planning is strongly affected by the inseparability of politics and "collective space" (Bohigas 2004). Ildefons Cerda's 1859 plan for Barcelona, installed equally spaced 100 m by 100-m blocks distributed public spaces equitably, at each block patio and at each chamfered street intersection (de Sola Morales 2008). However, small-scale considerations for human experience such as chamfers, have been gradually undermined by the increasing presence of cars. Following the establishment of a new Spanish Constitution in 1978, the city improved many small public spaces for citizens to enjoy on their return home from work, restoring many small plazas, replacing densely parked cars with new paving materials, benches, trees, vegetation, and drinking fountains, and reestablishing identity with adjacent historic buildings (Moix 1994). These spaces, along with the streetscapes of the previously autonomous villages (~~Author~~ 2013), reestablished places of refuge for pedestrians after the 1992 Olympic Games (Harvey and Smith 2005), (Smith 2009). Later initiatives included the 22@ district planning with minimum block requirements of 10% open space, social housing, and social services, as well as protected historic buildings and more recent smart approaches to block self-sufficiency (Guallart 2010). These initiatives mean that today planning in Barcelona is underpinned by an expectation of small-scaled urban places (Figure 2).

Superilles and their streets

Car exhaust fumes, brake, and tire particles contribute to neurological and respiratory illnesses in children (Sunyer et al. 2015; Catanzaro 2016). According to World Health Organization, the air in central Barcelona has an annual mean concentration of particulate matter of 56, surpassing both Los Angeles at 20 and New York at 14 (Mathiesen 2015). In response, the City of Barcelona has been trying to create *Eixample* streets that are healthier places to walk, live, and socialize.

Figure 1. Left: Barcelona's *eixample* blocks, *superilles* and interior streets. Right: Two *superilles* measured 2014.

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Figure 2. People eating and socializing in a plaza in the previously autonomous village of Gràcia, Barcelona.

With the help of data analytics, the City has planned *superilles* ("super-islands"), new three-by-three block (Bausells 2016) pedestrian areas by limiting vehicle access to perimeter streets using newly designed intersections that could match in size and quality the plazas in Gràcia as spaces of "placer," or human pleasure (Barcelona *Superilla* Plan 2014). The city's bus and bike lane systems were completely rerouted to match the new orthogonal *superilles* plan. New urban units now match the population density and complexity of many Catalan villages with between 15,000 and 30,000 inhabitants (Barcelona *Superilla* Plan 2014. The social interactions identified by the City in the plazas of Gràcia, however, have not yet been studied in any depth yet. Currently, the City has completed the analysis of only one *superilla* (Agencia 2016).

Pueblo livability

The *Eixample* grid unifies the streets of Barcelona, but it also masks key differences. As the city government aims to make more livable, walkable pedestrian islands free of vehicles, specific design qualities will need to be identified, measured, and supported at street scale. What is the existing texture of the small-grained social environment needed in order to attach to place, for example, (Latour 2005), (Manzo and Perkins, 2006)? What are the differences within and between individual *superilles*? What new understandings may be gained using point data within the streets of a *superilla*?

The *superilla* plan published by the city explicitly identifies the livability and social interaction of plazas located in the previously autonomous village of Gràcia located just above the *Eixample* (Barcelona *Superilla* 2015). As a result the Plaça del Sol, Plaça Revolució, and Plaça de la Vila de Gràcia were chosen as baseline comparison areas to better understand the relative analysis of the two Barcelona *Superilles* final data in 2015. Likewise, two exemplary streets, Carrer de Enric de Granados and Passeig de Sant Joan were measured with analytical diagrams done only for Carrer de Enric de Granados.

The research first tested data collection in the summer of 2014 for two adjacent *superilles* in the Poblenou waterfront neighborhood of the *Eixample grid*. In the summer of 2015, two new comparison *superilles,* one in Poblenou and one in the downtown Eixample Esquerra, were studied and used for the final results shown here. The 2015 *Eixample Esquerra Superilla* was located downtown between Carrer de Compte d'Urgell to Carrer de Muntaner, and Gran

Figure 3. *Superilla* plan in white streets. 2015 study *superilles* 01 and 02. Three Gràcia neighborhoods are identified with three red plazas. Three streets along Enric de Granados are also dark red. Street morphologies of other previously semi-autonomous villages are seen at the perimeter of the *eixample* grid and under *superilla* 02.

Via de les Cortes de Catalanes to Carrer de'Aragó. The 2015 *Poblenou superilla* was located between Carrere de la Llacuna and Carrer de Bilbao, and between Carrer de Doctor Trueta and Carrer de Pujades. It is worth noting that the Poblenou *superilla* is also located across one narrow street of dense storefronts predating the *Eixample* grid of a previous Poblenou fishing village and new 22@ district block planning (Figure 3).

Theoretical context

The pedestrianized street component of *superilles* can be compared to similar ideas in other countries. The Netherland's *woonerf* streets include traffic calming (Pharoah and Russell 1991). *Woonerf* are similar to *home zones* in the UK, where the needs of pedestrians, cyclists, children, and residents are met by reducing the presence of cars (Hebbert 2005). Other street models include *living street*s, in the UK, where pedestrians and cyclists are encouraged to use streets together (Pooley 2013). In the US, *complete streets* mix similar pedestrian, cyclist, cars, and delivery vehicles in a strategy that emphasizes safety, health, economic and environmental outcomes (~~McCann and LaPlante 2008~~). Barcelona's *superilles* share many of the AQ4 same objectives: reducing the dominance of vehicles, mixing transit modes, and improving environment and experience of streets for pedestrians, but *superilles*, being specific to Barcelona's *eixample* intersections, create new places the size of Gràcia plazas (Agencia 2016).

Social interaction describes the connective networks and structures of human social behaviors. Recent urban design research has been investigating dynamic social behaviors at street scale (Gehl 2006), (Franck and Stevens 2007), (Hou 2010), (Carmona et al. 2010), (Seamon ~~and Manzo 2014)~~. Early methods of measuring social behaviors in public spaces AQ5 included on-site video recording (Whyte 1980), and diagrams of people and cars (Appleyard 1980). These methods of directly monitoring human behaviors in urban spaces led to more recent surveying techniques that instead measure the *affordance* (Gehl 2006) of the spaces themselves to support different types of behavior (Gehl 2010). Streets, according to Gehl, should "change the mindsets of people." The work presented here primarily used the second type of measurement. AQ6 AQ7

The notion that equitable access to a diversity of social interactions is essential to creating healthy urban spaces traces its roots to Ramon Margalef's ideas of biodiversity, the importance of information, pollution as a condition outside a system, flows of energy, and people (Ros, 2001), and the sociological ideas of Folch (2012). The objective, according to Rueda, is "to create the conditions to found the equal opportunities by right of sex, age, race, religion, physical conditions …." (Rueda 2002). These ideas of diversity are similar to Jane Jacobs' four conditions of diversity: (1) the district must serve more than one primary use, and preferably more than two uses; (2) short streets/blocks that enhance a diversity of route choices and experiences; (3) building fabric should be mixed by age, condition, and required economic yield; and (4) population density (Jacobs 1961). Both theories assume social cohesion as a prime objective, although Jacobs' approach differs in her method of street level observation.

Space Syntax likewise aims to find a computational methods to understand social aspects of cities, including spatial patterns, pedestrian routes, and access to street-level commerce (Hillier and Hanson 1984). However, Space Syntax models predict social experience rather than measuring access to social resources. The methods presented here differ in: (1) focusing on social interaction, (2) on-site measuring integrated with GIS data; and (3) being used for the comparative *social* analysis of morphologically *similar* spaces. In using remote sensing and mobile computing to complement traditional GIS data, the work resembles approaches used by the MIT SENSEable Cities Lab, Columbia University Spatial Information Design Lab, and University College London's CASA Lab. Using numerical rating, counting, and statistical normalization, the method used more closely matches that of planners Reid Ewing, Susan Hardy, and others in measuring qualities of walkability (2009), although that work used video-recording and was less focused on visualization. AQ8

The specific framework used in the research presented here emerged from meetings with Salvador Rueda, and in particular his written description of social cohesion in *Guia Methodologica* (2012), as well as adaptations made by the author to make framework more widely applicable to other cities in Europe and the United States. A modified theory of social interaction was created based on the following parameters of urban environments: (1) access to employment, social spaces, services, and housing; (2) income and culture; and (3) transportation and information technology (see Figure 4). We then proceeded to measure the *accessibility* of these resources in *superilles* compared to other comparable, but traditionally planned districts of Barcelona.

Methods

The research presented here describes a specific method used to measure social interaction within Salvador Rueda's broader *Methodological Guide for Accreditation Systems Audit and Certification of Quality and Sustainability in the Urban Environment* (Rueda et al. 2012). The method used geospatial information collected at on-site street addresses to identify

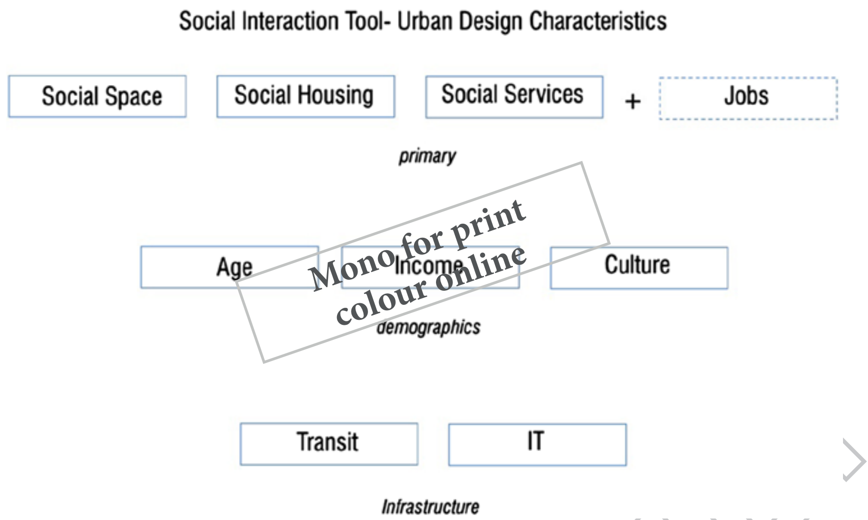

Figure 4. Theoretical framework for measuring social interaction. Dashed categories are newly added.

deficiencies in affordance of social resources, and to test the potential usefulness of combining mobile data gathering and cloud-based geospatial analysis in urban design.

The research aimed to understand small-scale differences between streets within and between *superilles*. The method was empirically based on repeat visits to 50 plazas and streets in Barcelona and Granada. Final data-sets recorded approximately 15,000 human-entered data values for each of the primary case study areas. Indicators were measured broadly (Creswell and Plano Clark 2010; Carmona 2015) between qualitative and quantitative phenomena. Analysis, synthesis, and evaluation (Lawson 2006) were employed at intermediate stages, before final computations were made. Iterative solutions (Lawson 2006) and "design patterns" (Woodbury 2010) were repeated.

The use of parametric workflows provided continuity (Woodbury 2010) and integration (~~Author~~ and Germany 2016), using "see-move-see" iterations (Schön 1987), and more than 30 research and student projects. The pilot data-sets and comprehensive research tools were refined over three years. The objective was to empower the researchers' decision-making process through iterations and frequent re-evaluations of the effectiveness of the work.

Because of its open, systematic and experiential benefits, a geospatial information system approach, using Rhino 3D and Grasshopper parametric software, was chosen to measure, codify, and visualize data (~~Author~~ 2016). The research software's spatial scale aligned well with that of the data and the custom visualization of the work. New on-site data were created from three sources: (1) single sourced, such as cell data; (2) a variety of different sources; and (3) from scratch (Nabian et al. 2013). In many cases, the data did not exist in municipal records. Demographic data, for example, exist at the scale of census tracks, but not streets. AQ9

In order to determine the ability of streets to support diverse social interaction sub categories and indicators were created within the primary uses, demographic, and infrastructure categories (see Figure 4). Importantly, the phenomena of social interaction were not directly measured. The research team's previous work on relationships between pollution and urban experience had created an iterative knowledge of indicator testing, and this enabled us to create a process of quantitative to qualitative codification.

Coding methods used yes/no (0/1); ratings (0–5); and numerical quantities, including currency and spatial areas, typologies, indexes, and syntax matches. Data dictionaries were also used, including "coding type" and "units," describing a strict protocol for data gatherers. Data-sets were gathered for each primary study area, whenever possible by one data gatherer measuring each set of indicators over a 3–5-day period. Data-sets were tested in pilot visits to individual streets by data gathers with expertise in a specific type of data collection. Data collection varied significantly by discipline. Landscape architectural knowledge, for example, was used to record indicators of tree health, through leaf examination, and ratios of tree species height, canopy, and trunk diameter (Table 1 and Figure 5). AQ10

Table 1. Category hierarchy: PRIMARY qualities in caps; Secondary qualities in sentence case; Pu = Public, Pr = Private; indicators listed in lower case.

Uses	Demographics	Infrastructure
Space	*Age*	*Transit*
Pu	Pu/Pr	Pu
Tree species	Seniors (55+)	Sidewalk width
Tree height	Adults (31–55)	Bike_street friendly
Other plantings	Young adults (21–30)	Parking_on-street
Health, pollution or draught	Teenagers (13–20)	Bus
Sound source, dominant	Children (0–12)	Emx(bus rapid transit)/streetcar
		Subway
Exterior seating +		
Lighting +		
Kid friendliness +		
Pr (Ray Oldenburg)		Pr
Name		Buffer/safety
# Occupancy		Bike_parking
Seating type		Parking_off-street
# Employees		
Comfort		
Character		
Housing	*Income*	*Information Technology++*
Pu	Pu	Pu
Public Housing	high (€) meal	Free public Wi-Fi
	low (€$) meal	Fiber optic bandwidth
Pr	Pr (USDA food dessert index)	Pr
Housing type	Milk (liter)	Cell strength
Housing diversity	Eggs (dozen)	Free private Wi-Fi
Bath	Vegetable 1 – potatoes (per kilo)	
Bedroom #	Vegetable 2 – apples (per kilo)	
# floors	Coffee (café solo)	
Area	Beer (330 ml)	
Cost per m^2		
Rental cost		
Services	*Cultural Background*	*Basic Needs++*
Pu	Foreignness	Toilet+
Public service	Parent's birthplace	Drinking water +
Pr	Birthplace	Shelter +
Service type	Language name	
Name		
Public/private		
Job Access++		
Pu		
Job type +		
# of floors +		
Access +		
Signage +		

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Urban Character	Category	Public/Private	Variable	Indicator	Coding Type	Unit	On_Off_Site
1 Social_Space	22@	Public	Vegetation	Species	type	1-19	On
2 Social_Space	22@	Public	Vegetation	Height	height by floor	stories	On
3 Social_Space	22@	Public	Vegetation	Health	type	0-2	On
4 Social_Space	22@	Public	Vegetation	Color	type	0-3	On
4 Social_Space	22@	Public	Vegetation	Sound (birds, etc)	yes/no	0/1	On
5 Social_Space	22@	Public	Sound	Decibel	number	db	On
6 Social_Space	22@	Public	Sound	Frequency	number	hz	On
7 Social_Space	22@	Public	Sound	Source			On
8 Social_Space	22@	Private	3rd_Space	Name	text		On_Off
9 Social_Space	22@	Private	3rd_Space	Type	type	0-5	On_Off
10 Social_Space	22@	Private	3rd_Space	Occupancy	number	#	On_Off
11 Social_Space	22@	Private	3rd_Space	Seating_Arrangement	type	0-4	On
12 Social_Space	22@	Private	3rd_Space	Number_Employees	number	#	On_Off
13 Social_Space	22@	Private	3rd_Space	Comfort_Level	type	0-5	On
14 Social_Space	22@	Private	3rd_Space	Playfulness	type	0-5	On

Figure 5. Codification.

Data analysis – rating, formulation, and visualization

Formulation of analysis for each indicator relied on the initial principle of diverse accessibility equating data of different types, quantities, and syntax to measure social interaction. A general approach to this was established for each of these primary types of formulation. For example, while 13 *business types* were possible, a street could achieve a maximum rating by reaching a threshold, or gate, of seven different types. A total number below seven different *business types* resulted in a proportionately lower value. Similar numerical ratings, quantities, medians, and averages were used. Formulation was then brought into the geospatial information software where they could be associated with each geospatial point. Formulation of data was done in spreadsheets when possible but eventually done natively in the Rhino 3D Grasshopper environment. Table 2 shows the formulation for each indicator. All scoring was done for a given street along a single block. Scores for the 12 interior streets were then averaged for the final superilla score. The following scoring approaches were used:

Threshold/gating

Typological diversity was calculated using a threshold, or gate, often achieving full value using the median number of types. Scores were prorated as a percentage of that threshold. Examples of indicators included tree species and height types, seating and occupancy types, number of employees, housing types such as number of floors, bedrooms, and bathrooms and building type.

Scoring mean

Ratings used a scoring mean to average the total score. Ratings described a quality of a place to support a sociological behavior. The question of "ability to" do an activity was often asked. The rating method relied on a carefully tested and refined data dictionary to describe each rating for an indicator. Examples of *scoring mean* included vegetation heath, source of sound, kid friendliness, lighting, exterior seating, comfort level, character, bike parking, on-street parking, off-street parking, differently abled, street buffer, sidewalk width, toilet access, water access, shelter, cell strength, public Wi-Fi, and free private Wi-Fi.

Table 2. Formulation for each indicator.

USES	Social Space	Tree Species	Input (types of tree species)	# of types	Gating {0=0, 1=.5, 2=.75, +3=1		
USES	Social Space	Tree Height	Input (tree height in stories)	# of types	Gating {0=0, 1=.5, 2=.75, +3=1		
USES	Social Space	Other Vegetation	Input (category of other Veg)	Input Scoring (none =0, some = 1, dense +2)	Scoring Mean		
USES	Social Space	Vegetation Health	Input (category of health)	Input Scoring (poor=1, medium=2, good=3)	Scoring Mean		
USES	Social Space	Source of Sound	Input (source of sound)	Input scoring (bird/leaves=3, people=2, traffic=1)	Scoring Mean		
USES	Social Space	Kid Friendliness	Input (rating 1–3)	Scoring Mean			
USES	Social Space	Lighting	Input (rating 1–3)	Scoring Mean			
USES	Social Space	Exterior Seating	Input (rating 1–3)	Scoring Mean			
USES	Social Space	Density	Input (names of stores)	Number of Stores	Scoring Mean		
USES	Social Space	Max occupancy	Input (number of seats)	Block Sum	Gating {0=0,1–10=.5, 11–50=.75, +51=1		
USES	Social Space	Seating Type	Input (types of seats)	# of types	Gating {0=0, 1=.5, 2=.75, +3=1		
USES	Social Space	Number of Employees	Input (number of employees)	Employee Sum	Gating { 0=0, 1–5=.5, 6–20=.75, +21=1		
USES	Social Space	Comfort Level	Input (rating 1–5)	Scoring Mean			
USES	Social Space	Character	Input (rating 1–5)	Scoring Mean			
USES	Social Housing	Rental Cost	Input (monthly rent)	Block Mean	Percentage of High (monthly cost constant)	Inverse	
USES	Social Housing	Area	Input (area)	Diversity (area range as type)	Standard Deviation	Average Deviation	Inverse
USES	Social Housing	Cost per sq. ft.	Input (Cost per sq. ft.)	Block Mean	Percentage of High (Cost per sq. ft)	Inverse	
USES	Social Housing	Number of Floors	Input (# of floors)	Building Height Diversity	Gating { 0=0, 1=.75, +2=1		
USES	Social Housing	Number of Beds	Input (# of beds)	Number of bed diversity	Gating { 0=0, 1=.75, +2=1		
USES	Social Housing	Number of Bathrooms	Input (# of bathrooms)	Number of bathroom diversity	Gating { 0=0, 1=.75, +2=1		
USES	Social Housing	Housing Type	Input (types of housing)	# of types	Gating { 0=0, 1=.6, 2=1		
USES	Social Services	Density of Services	Input (service vs nonservice)	Number of Services	Percentage of Data Points		
USES	Social Services	Service Type	Input (types of services)	Input Scoring	Standard Deviation	Average Deviation	Inverse
USES	Social Services	Public vs Private Services	Input (public vs private)	Input Scoring (private=1, public=2)	Standard Deviation	Average Deviation	Inverse
USES	Social Services	Youth Service	Input (educational services)	Percentage of Data Points			
USES	Jobs	Job Type	Input (types of jobs)	Input Scoring	Standard Deviation	Average Deviation	Inverse
USES	Jobs	Number of Floors	Input (# of floors)	Standard Deviation	Average Deviation	Inverse	
USES	Jobs	Access	Input (public vs private)	Input Scoring (private=1, public=2)	Standard Deviation	Average Deviation	Inverse
USES	Jobs	Signage	Input (Presence of Sign)	Percentage of Businesses			
DEMOGRAPHICS	Culture	Language of Business Name	Input (language)	Input Scoring (English=1, Spanish=2, Other=3)	Standard Deviation	Average Deviation	Inverse

(*Continued*)

Table 2. (*Continued*).

DEMOGRAPHICS	Culture	Language of Menu	Input (number of languages)	Gating { 0=0, 1=.5, 2<x=1	
DEMOGRAPHICS	Culture	Birthplace	Input (number of languages)	Gating { 0=0, 1=.5, 2<x=1	
DEMOGRAPHICS	Culture	Parents' Birthplace	Input (number of languages)	Gating { 0=0, 1=.5, 2<x=1	
DEMOGRAPHICS	Culture	Foreignness	Input (45–48)	Scoring Mean	
DEMOGRAPHICS	Age	Ages 0–12	Input (rating 0–2)	Scoring Mean	
DEMOGRAPHICS	Age	Ages 13–20	Input (rating 0–2)	Scoring Mean	
DEMOGRAPHICS	Age	Ages 21–30	Input (rating 0–2)	Scoring Mean	
DEMOGRAPHICS	Age	Ages 31–50	Input (rating 0–2)	Scoring Mean	
DEMOGRAPHICS	Age	Ages 51+	Input (rating 0–2)	Scoring Mean	
DEMOGRAPHICS	Income	Cost of Beer	Input (price)	Block Mean	Percentage of study area high
DEMOGRAPHICS	Income	Cost of Coffee	Input (price)	Block Mean	Percentage of study area high
DEMOGRAPHICS	Income	Cost of Apples	Input (price)	Block Mean	Percentage of study area high
DEMOGRAPHICS	Income	Cost of Potatoes	Input (price)	Block Mean	Percentage of study area high
DEMOGRAPHICS	Income	Cost of Eggs	Input (price)	Block Mean	Percentage of study area high
DEMOGRAPHICS	Income	Cost of Milk	Input (price)	Block Mean	Percentage of study area high
DEMOGRAPHICS	Income	Cost of a Cheap Meal	Input (price)	Block Mean	Percentage of study area high
DEMOGRAPHICS	Income	Cost of an Expensive Meal	Input (price)	Block Mean	Percentage of study area high
INFRASTRUCTURE	Transit	Bike Parking	Input (type of bike parking)	Input Scoring	Block Mean
INFRASTRUCTURE	Transit	Bike Street Friendly	Input (rating 1–3)	Block Mean	
INFRASTRUCTURE	Transit	On-Street Parking	Input (type of parking)	Input Scoring (yes=1, no=2)	Block Mean
INFRASTRUCTURE	Transit	Off-Street Parking	Input	Input Scoring (yes=1, no=2)	Block Mean
INFRASTRUCTURE	Transit	Differently Abled	Input (rating 1–3)	Block Mean	
INFRASTRUCTURE	Transit	Street Buffer	Input (rating 1–5)	Block Mean	
INFRASTRUCTURE	Transit	Sidewalk Width	Input (width in feet)	Block Mean	
INFRASTRUCTURE	Transit	Bus Stops	Input (1-yes/0-no)	Number per Block	
INFRASTRUCTURE	Transit	Metro Stops	Input (1-yes/0-no)	Number per Block	
INFRASTRUCTURE	Basic Needs	Toilet Access	Input (rating 1–4)	Block Mean	
INFRASTRUCTURE	Basic Needs	Water Access	Input (rating 1–4)	Block Mean	
INFRASTRUCTURE	Basic Needs	Shelter	Input (rating 1–4)	Block Mean	
INFRASTRUCTURE	IT	Cell Strength	Input (bars 1–5)	Block Mean	
INFRASTRUCTURE	IT	Public Wi-Fi	Input (1-yes/0-no)	Block Mean	
INFRASTRUCTURE	IT	Free Private Wi-Fi	Input (1-yes/0-no)	Block Mean	

Percentage of high score

Relative accessibility within a study area was measured using a percentage of the high score for that area. The degree of heterogeneity was desired for these indicators, measuring a relative diversity for each street within the overall range of values gathered for that study area. These examples all used *scoring mean* and subsequently *percentage of high score* and included the cost of beer, coffee, vegetables, eggs, milk, and an inexpensive meal and expensive meal at a given food establishment.

Percentage of data points

Density of proximate *services* used a percentage of data points for a given street area. This scoring measured the relative number of services for an area which often characterizes a neighborhood or area. Similarly, in the case of *signage* presence, the *percentage of businesses* was used as a basis was used.

Standard deviation/average deviation

Standard deviation was used to measure how different a location scored against an average for its overall study area. Standard deviation was always followed by average deviation for calculations. Examples of the use of standard deviation included service type, public versus private services, job type, physical street-level access, and language of business name.

Number per block

Absolute measurement would count the number of instances per block. These absolute values were done when a score of one or more would result in a positive score often related to walkable access to transit such as a presence of metro stops or bus stops.

Inverse

The evaluation of positive or negative impact to the diversity of social interaction was assessed. In most cases the rating systems provided a positive rating. In other cases a higher rating meant a more negative impact. In such cases an inverse calculation was used. Examples included housing cost per square foot.

Understanding fine-grain differences through visualization

The Barcelona case study was examined through either one or two *superilles*, and compared with a number of other exemplary districts known for their social interaction. The circle diagrams owe their method of visual language to computer scientist Manuel Lima's *Visual Complexity* (2011). Circle and plan diagrams were analyzed and visualized as city blocks but shifted to the experiential space of streets. It became apparent that this new scale of urban data collection naturally led in turn to new scales of urban data analysis and visualization. While many urbanists have studied the small scale of public space, either streets or plazas, few examples exist of GIS methods or visualizations at this street scale. The visualization language differentiated or associated information using: (1) various axes of circular spatial organization, (2) color, and (3) lines, for each street measurement and tonal background area to average the scores of streets within a *superilla*.

Data and observed emergent patterns of social interaction

The same indicators were used on the *superilles* and comparative districts. Each indicator reflected one way to measure a desired quality. For example, to measure the visual appeal of a social space, the study measured diversity of *tree species* and *other planting* (*leaf color, flower coloration* could also have been used). In another city, other indicators might well be used. In each location impressionistic and comparative understandings were always established onsite, prior to final data gathering in order to test how to determine indicators, their relevance, the effect of morphology, and other variables. Reading the data from the diagrams included a range of methods (Figure 6):

- *Circle Diagrams* were compared between *superilles* and between *superilles* and comparison spaces, using the visual hierarchy of primary, secondary, and indicator groupings.
- *Spreadsheet Data Bases* were used to compare statistical averages between comparison areas.
- *Street Plans* were used to visualize the data points.

Superilla Poblenou compared to Superilla Eixample Esquerra

- *USES – Sensory Engagement*. Indicators of the secondary category *Space* measured the diversity of spatial experience. When comparing the diagrams of data for the Poblenou *superilla* and the Eixample Esquerra *superilla*, a higher access of *exterior seating* (2.05 and 1.3) is seen for Poblenou. Higher diversity of *dominant source of noise* and *other vegetation* are also evident, suggesting greater "sensory invitation" (Gehl 2006) for people to hear a variety of natural, human, and non-human noises. Indicators of *trees species* and *tree height*, are similar, perhaps explained by the consistent city regulation and maintenance of such qualities in Barcelona. Indicators of private third-spaces such as average *maximum occupancy* (63 and 55), *comfort level*, and the *number of employees* are higher in Poblenou. AQ11
- *DEMOGRAPHICS – Affordable Staples*. Data for Poblenou measured greater *income access* to food staples prices for *vegetables (tomatoes and potatoes)*, *milk*, and *eggs* (4.80€ and 6.91€), as well as the average *cost of coffee* (1.11€ and 1.34€) and *cost of beer* (1.52€ and 2.10€). The average *most expensive meal* was more accessible in Poblenou (14.79€ and 20.l6€), while the average *least expensive meal* was similar (3.97€ and 4.02€). However, the average *rental price per meter squared* was similar (13.84€ and 14.72€) despite the Eixample Esquerra's more central downtown location. Indicators of cultural background were similar with *birthplace of owner* (2.13 and 2.20) and *menu languages* rating (1.25 and 1.30) between Poblenou and Eixample Esquerra.
- *INFRASTRUCTURE – Pedestrian centric*: Transit indicators revealed detailed differences of more pedestrian friendliness in Poblenou but more traditional transit access in Eixample Esquerra. Poblenou scored higher than Eixample Esquerra in *bike friendliness* and *bike parking* but lower in access to *on-street parking* and *off-street parking*, *bus stops*, and

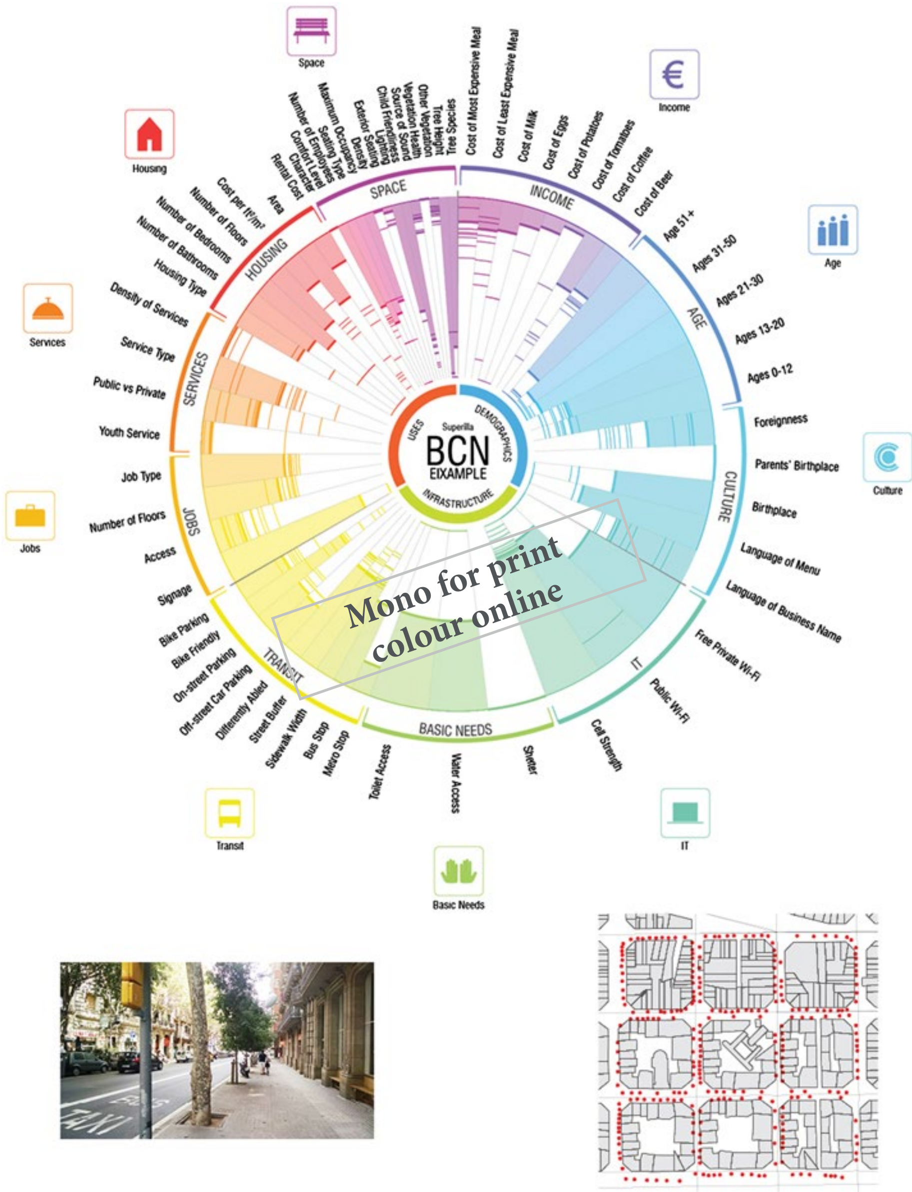

Figure 6. Barcelona – *Eixample* Esquera *Superilla*.

metro stop access. Pedestrian access such as *sidewalk width* and *street buffers* were similar, again possibly pointing to qualities more regulated by the City. Information Technology infrastructure was similar but *free-private Wi-Fi* was higher in Eixample Esquerra.

These results reveal how Poblenou, as a previously autonomous pueblo, exhibits a wide range of livable qualities, including *sensory engagement*, *affordable staples*, and *pedestrian centric* transit. The Poblenou *superilla* data suggest that the pueblo experience is possible within the morphology of the *Eixample* grid. The comparison may also reveal the effects on social interaction of differences in local government regulations and traditions of private

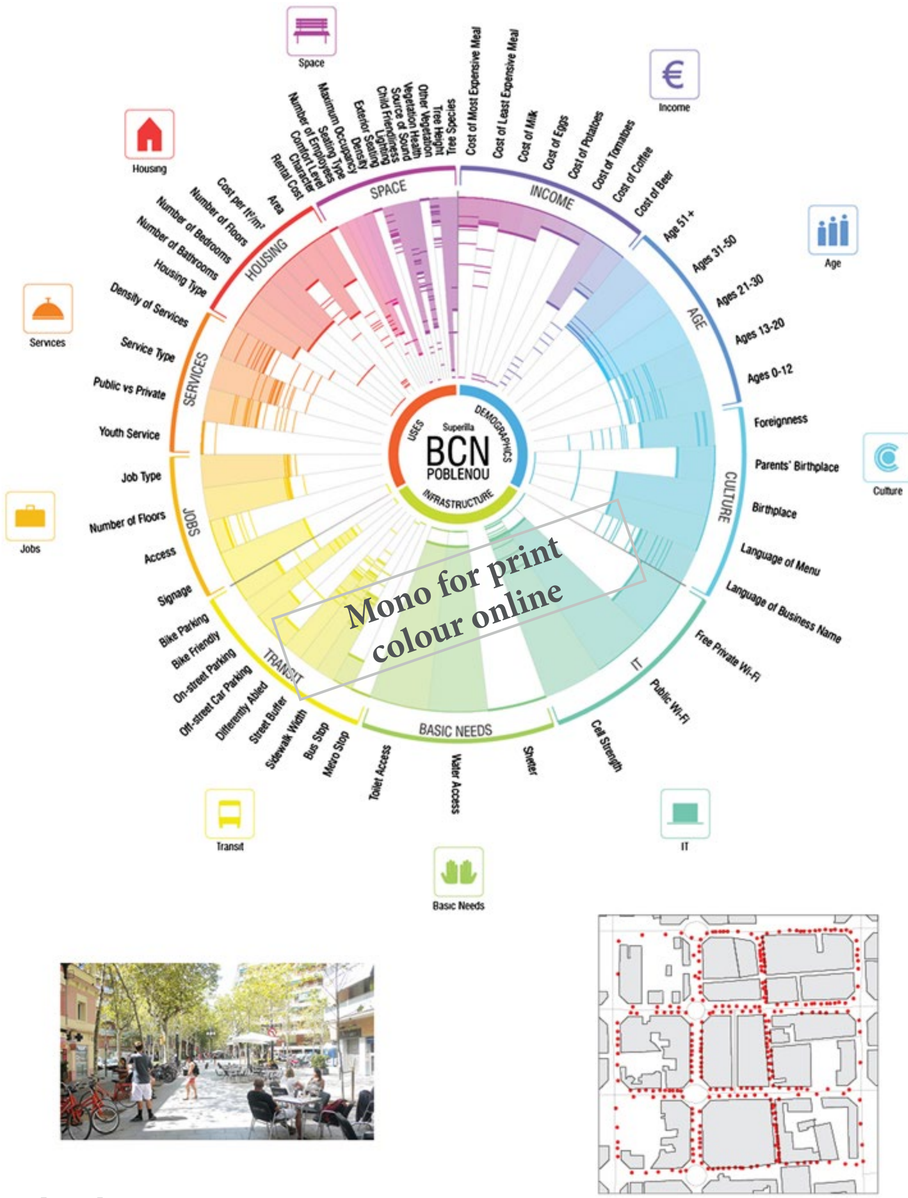

Figure 7. Barcelona – Eixample Esquera *Superilla*.

space usage. Clues to geospatial differences at an even smaller scale were found within the *superilles*. For example, the visualization diagrams suggest significant differences in access to social resources between different areas of the *superilla* (Figure 8).

Morphological understanding

While traditional planning includes unexperienced spaces, the high resolution of data indicators of social interaction may now be examined within the spatial experience of streets.

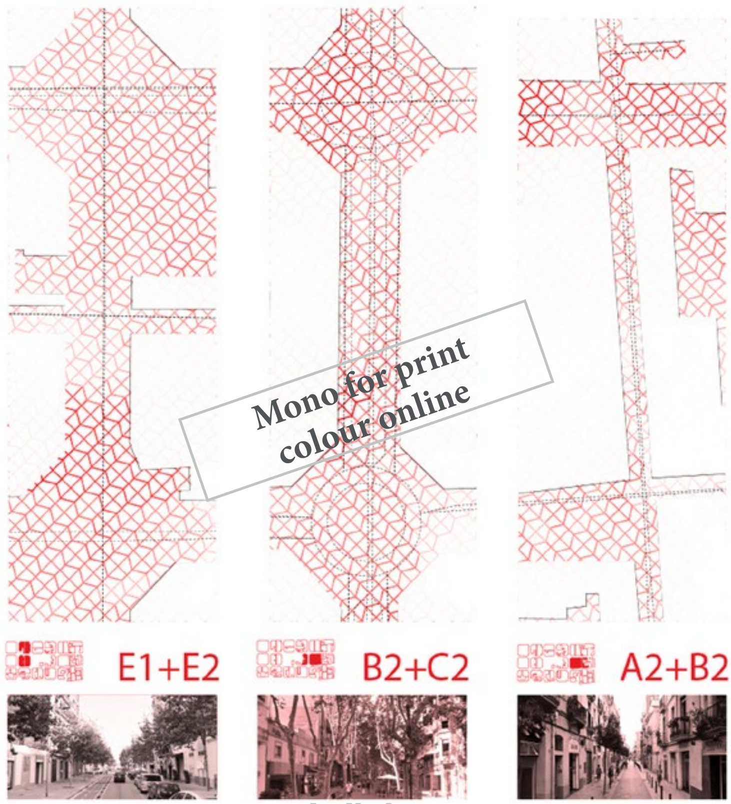

Figure 8. Barcelona, Poblenou *Superilla*, three street morphologies.

The quality of *free private Wi-Fi* visualized in the Poblenou *superilla*, for example, reveals small-scale differences that could relate to: (1) differences street morphologies between the 13th C. Maria Aguilo (right), the 19th C. Rambla Poblenou (center), and the 20th C. *Eixample Plan*/21st C. *22@ Plan* Carrer de la Llacuna (left) (see Figure 7). Small, densely spaced shops line Maria Aguilo, while *free private Wi-Fi* is more accessible along Rambla Poblenou (Figure 9).

Superilles compared to Gràcia Plazas

Barcelona's *superilla* publication included Gràcia plazas as exemplary spaces of social interaction, and informed our decision to use them as baseline comparison areas. Their popularity for social interaction is exemplified by two periodic events: (1) weekend leisure and (2) the annual Feste de Gràcia, a week-long festival celebrated in over 40 streets and plazas.

Each proposed *superilla* would create up to four interior plazas by limiting vehicular access and reclaiming space from double parked taxis and private automobiles. These new plazas would be as large or larger than most of the plazas in Gràcia (Agencia 2016). For the purposes of comparison, the *superilla* Poblenou, with its higher pedestrian rating, was chosen to compare with the Gràcia neighborhoods *Plaça del Sol*, *Plaça de la Vila de Grâcia*, and *Plaça de la Revolució de 1868*.

Figure 9. Comparison spaces: Gràcia's *Plaça del Sol*; *Plaça de la Vila de Grâcia* and *Plaça de la Revolució de 1868*.

- *INFRASTRUCTURE – Urban refuges:* The new transit qualities of walkability and bikability are exemplary in Gràcia and follow the general pattern of Poblenou's village history rather than Eixample Esquerra. The Gràcia plazas create hospitable enclaves for diverse social activities. The indicators of *street buffer* and *bike friendliness* consistently rated higher in Gràcia plazas than the Poblenou *superilla*. Meanwhile, access to *bus stops*, *metro stations*, and *off-street car parking* were almost nonexistent in Gràcia. These qualities in combination with an urban morphology of discontinuous streets, creates a welcome feeling of *urban refuge*. In these small, isolated plazas one observes children playing, seniors resting, and young adults socializing. *Free Wi-Fi* ratings varied widely, between high, low, and zero.
- *USES – Meeting places: Lighting* and *sources of sound* were at their highest levels in Gràcia. In private third-spaces, *maximum occupancy* and diversity of *seating type* were also high. Conversely, *tree height* and *other vegetation* often rated lower in Gràcia than in Poblenou. The diversity of tree species was similar. General indicators of access to housing were similar. Services and jobs indicators were lower, and sometimes immeasurable. The smaller plazas, such as Plaza del Sol, for example, had fewer services or job types, possibly because of the small number of addresses in each plaza, but also because of their relatively long distance from metro and bus stops.
- *DEMOGRAPHICS – Income Diversity:* Gràcia plazas are a venue for a broad range of activities during the day and diverse meal and entertainment activities at night, often accessed by foot. Income accessibility for *meals*, *coffee*, and *beer* was diverse, with the three Gràcia plazas broadly measuring higher, lower, and no data values when compared to the Poblenou *superilla*. Few Gràcia plazas offered food staples for sale immediately within the plazas, but when they did, in the Plaza de la Vila de Gràcia, for example, the prices of milk and eggs were more accessible than either Poblenou or Eixample Esquerra *superilla*. Cultural indicators were similar, except that the diversity of menus *languages* was higher. *Language of business name* and *birthplace* were slightly lower than either Poblenou or Eixample Esquerra.

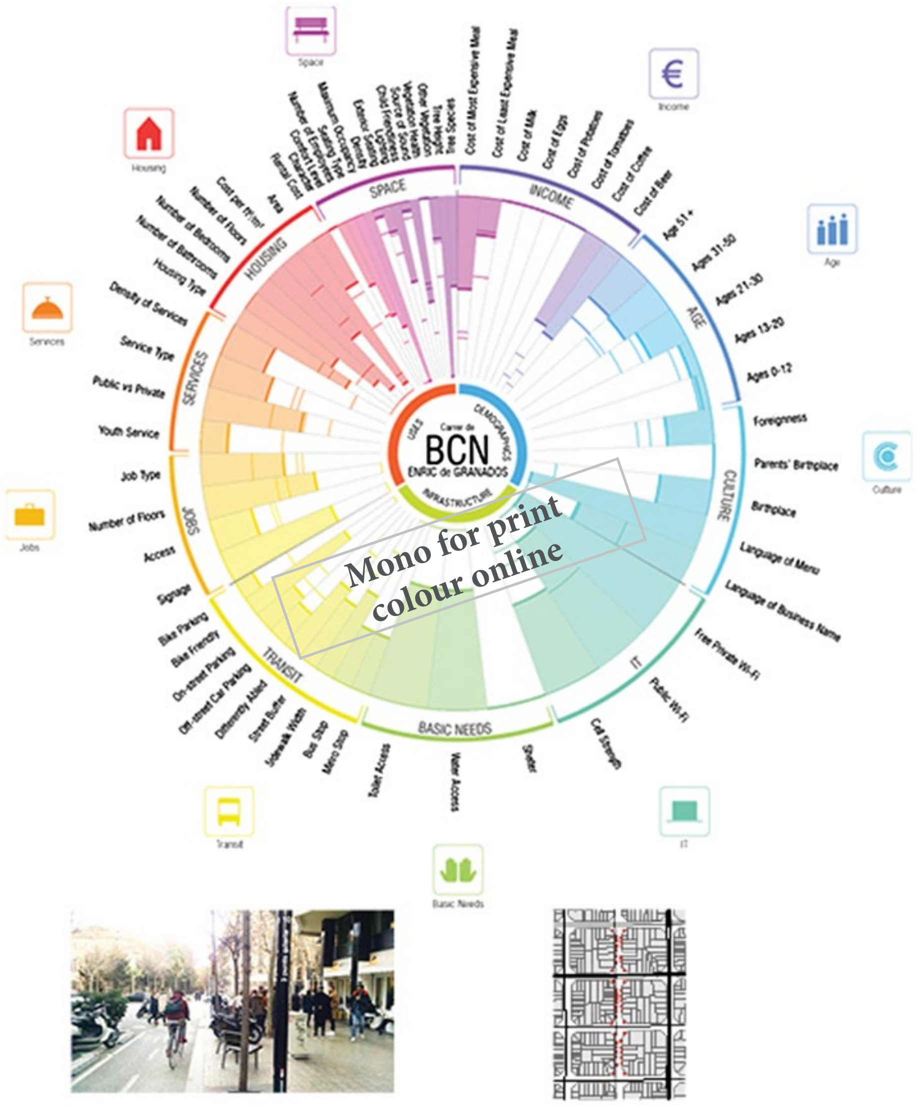

Figure 10. Barcelona comparison street: *Carrer de Enric de Granados*.

The data often revealed resources that were lacking, but apparently not essential to social interaction. In Gràcia, for example, traditional transit, job diversity, and diverse vegetation may not be necessary for the successful experience of a successful place of social interaction (Figure 10).

Superilles compared to Carrer de Enric de Granados

Streets, like plazas, may support human scale of social interaction, but also mobility and the connectivity of a city. The street Carrer de Enric de Granados is recognized for its outdoor restaurant seating and pedestrian vitality as another *urban refuge* from vehicular dominance in the downtown Plan Cerda of Barcelona. It demonstrates flexibility within the typical street section of the Plan Cerda used for up to four lanes of traffic and/ or parking. Three blocks of Carrer de Enric de Granados were chosen for analyses between Carrer del Roselló and Carrer de València. The 22-m street sections are divided into broad sidewalks of 7 m on both sides of the street for walking and dining, one bike lane of 2 m, motorcycle and moped diagonal parking of 2 m, and only one vehicular lane of 3.5 m.

- *INFRASTRUCTURE –The New Transit and Data Provenace:* Diversity of traditional and non-traditional transit access was evident in the more fine-grained data of the diagrams. *Bus* and *metro stops* were more common than in the Poblenou *superilla*. Pedestrian access indicators of *street buffer* and *sidewalk width* were also both higher along Carrer de Enric de Granados. *Bike friendliness* was equally high. Surprisingly, access to *bike parking* was lower, but it had multiple bike share stations. Access to *free private Wi-Fi* along Enric de Granados achieved the highest values of the 2015 survey. Access to *public Wi-Fi* was similar to Poblenou, suggesting an effective distribution of a public infrastructure. Private *cell strength* was lower.
- *USES – Meeting and Housing Diversity*: The indicators of accessible public space were similar, with *kid friendliness* rating lower in Enric de Granados but private third-space *maximum occupancy* rating highest of the survey, and *seating type* also higher. *Comfort level* was slightly lower. While housing *rental cost* access was slightly lower, the diversity of *area*, *number of floors*, *number of bedrooms*, *number of baths*, and *housing types* were drastically higher in Enric de Granados. *Services* were lower in Enric de Granados but indicators of job access were higher, especially the *number of floors*, *access*, and *signage*. Thusly, while common indicators of *rental costs* and *job types* were not more accessible, the finer-grained qualities were more accessible.
- *DEMOGRAPHICS – Exclusivity, Hipness:* As expected, indicator data for downtown income accessibility were lower. Comparing Enric de Granados with the Poblenou *superilla*, *income* accessibility indicators were less, including the average *cost of beer* (2.26€ and 1.52€) and *cost of coffee* (1.28€ and 1.11€). The accessibility of both *low-cost meals* (4.52€ and 3.97€) and *high-cost meals* (16.77€ and 14.79€) were also lower. Access to food staples along the three specific streets analyzed was almost non-existent. In fact, the data suggest that these particular streets have an exclusivity and high transit and IT infrastructures similar to those of other famously gentrified meeting places, such as Soho in New York, La Condessa in Mexico City, and Trastevere in Rome. *Cultural* indicators such as the *birthplace* of business owner *or parent's birthplace* of business owners were lower, while the range of *menu languages* was the highest of the survey, and the *language of business names* was much higher than in Poblenou. Carrer de Enric de Granados is internationally welcoming, but owned by locals. It is hip, inclusive to visit, but exclusive to live in.

The Enric de Granados results suggest that higher qualities of social interaction are possible within the Plan Cerda. Enric de Granados is a meeting place like Gràcia, but more fashionable, perhaps, because of its *new transit and data provenance*, diverse *meeting place and housing qualities*, and *exclusivity*. It may not be an area where everyone crosses paths to buy food staples, but it is a place to be felt exclusive, if only for a common meal or beer.

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Conclusions

A closer understanding of the human qualities of urban spaces and of how they support social interaction in particular offers benefits for designers, city authorities, and urban inhabitants. Urban designers, especially can potentially improve larger scaled traditional planning approaches through better understanding of human-scale qualities of spaces. The measurement of support for social phenomena reported in this research also represents a new use of mobile technology. The integration of on-site data with GIS-based analysis reveals patterns that are otherwise not included in traditional GIS planning techniques nor described by traditional behavioral science methods. In going onsite to identify, collect, and spatially integrate data, the methodology and software tools developed differ from the predictive modeling employed in urban analytics such as Space Syntax or surveying techniques.

Patterns emerged that visualize examples of *urban refuge*, *meeting places*, and *data provenance*. They revealed, for example, differences in the distribution of publicly versus privately afforded infrastructures. The study areas at the scale of streets and *superilles* also provided a demonstration of the contribution across small urban scales of the research methodology.

Social interaction and other urban phenomena measured on-site exemplifies an emerging "bottom-up" method of urban design, harnessing the power of small-scale geospatial information systems (Author 2014). While the use of predetermined indicators is somewhat prescriptive, they allow the measurement urban qualities across varying urban milieu (Gehl 2006). Indicators of the kind used can represent the capacity of environments to support any sort of positive human experience, and provide an important complement to the more traditional direct observation of urban phenomena.

Disclosure statement

No potential conflict of interest was reported by the author. AQ12

Notes on contributor

Philip Speranza is an architect, an urban designer, and an assistant professor in the Department of Architecture at the University of Oregon, where he teaches design studios in architecture and urban design, media courses in computation and data visualization, and directs the Barcelona Urban Design Summer Program. Speranza's research scholarship and creative work explore the use of new geospatial design methods to understand small-scale social and environmental phenomena in urban design. Speranza has published widely on this subject through diverse lenses including geospatial information and parametric design, on-site and off-site data acquisition, social interaction in Barcelona urban ecology, bike sharing and interaction design, air pollution visualization, adaptive urbanism and ethnicity, business fabric, place branding, time and architecture, and memorial design. Articles and book chapters on these topics are published in the *Journal of Urban Design*, *Architectural Design AD*, the *International Journal of Design Sciences and Technology*, and presented at annual meetings of the *Association of Computer-Aided Design in Architecture ACADIA*, the *Association of Collegiate Schools of Architecture ACSA*, *Environmental Design Research Association EDRA*, and the *Industrial Designers Society of America IDSA*. ~~Forthcoming publication venues include the *Journal of Urbanism*, the *Journal of Urban Design and Planning ICE*, and *Atmosphere Environment*.~~ This research is actively tested through Speranza's Eugene-based architecture practice that includes neighborhood planning design, plaza design, mixed-use developments, housing, and previous public art works with Janet Echelman between 2001 and 2010 in the US, Portugal, and Spain. Speranza received his professional MArch from Columbia GSAPP with the Award in Technology and a BS Arch from the University of Virginia. Prior to his independent practice, he worked with Steven Holl in New York and Carlos Ferrater in Barcelona. ~~He is the co-director of interdisciplinary work via the Urban Interactions Lab UIxD in Eugene and the Urban Design & Computing Lab in Barcelona studying air pollution, urbanism, and UAV robotics in Barcelona, Portland, and Eugene.~~

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