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The scales of the metropolis: Exploring cognitive maps using a qualitative approach based on SoftGIS software

Guillem Vich[a,*], Oriol Marquet[c], Carme Miralles-Guasch[a,b]

[a] Geography Department, Autonomous University of Barcelona, Cerdanyola del Vallès, 08193 Barcelona, Spain
[b] ICTA (Institute of Environmental Science and Technology). Cerdanyola del Vallès, 08193 Barcelona, Spain
[c] Department of Parks, Recreation and Tourism Management – North Carolina State University (NCSU), 2800 Faucette Dr., Raleigh, NC 27695, USA

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ABSTRACT

The spatial dimension of daily mobility depends on where people choose to perform their daily activities in urban environments. This study explores the influence of multiple geographical scales, characterising metropolitan regions on the cognitive images of individuals, whose daily mobility is restricted by an interurban daily commute to a university campus in the Metropolitan Region of Barcelona.

To do so, a sample of 28 adults from the Barcelona Metropolitan Region (RMB) were asked to describe perceived activity spaces using a combination of SoftGIS technology and interviews. Results have shown that different individuals can perceive the same geographic context in several manners, differentiating their utilised space between spatial continuums, fragmented territories or overlaid territories. Furthermore, factors such as the different spatial scales that affect a territory, the morphological characteristics of residential areas or the transport infrastructures, have proven to influence cognitive maps of individuals. Finally, different methods utilised for the exploration of cognitive maps have provided variations in the resulting cognitive images of participants.

1. Introduction

The spatial scale at which everyday activities are located determines the daily travel costs for residents of metropolitan regions and the consequent transport-related externalities (Banister, 2008; Ewing et al., 2016). Therefore, understanding the determinants affecting the spatial behaviour of metropolitan residents is essential for urban policymakers when tackling these externalities (Buliung and Kanaroglou, 2006).

As well as the environmental setting and the sociodemographic characteristics (Fan and Khattak, 2008), the structure of the extent of daily mobility of individuals, or *activity space* (Horton and Reynolds, 1971) is influenced by an individual's cognitive image of the real world (Downs and Stea, 1973). According to psychological and urban studies, the information required to understand where things are and how to get to where those things are is stored in the cognitive map of individuals, hence, becoming essential for spatial behaviour and decision-making (Gärling, 1989). In consequence, such decisions and behaviour have an effect on where to carry out daily activities, and the routes and the mode of transport to be utilised between destinations (Kitchin, 1994).

This study explores the influence of multiple geographical scales in metropolitan regions on the cognitive images of individuals. For this purpose, SoftGIS mapping exercises and interviews were used to obtain the cognitive maps of the territory utilised by a sample of 28 adults, whose daily mobility is constrained by an interurban daily trip to a university campus in the Barcelona Metropolitan Region (RMB).

This paper is structured as follows: Section 2 delves into the theoretical aspects of the concept of activity space and its explanatory factors, such as cognitive images. Section 3 contextualises the campus of the Autonomous University of Barcelona (UAB) within the RMB and the utilised methods and data for the analysis. Section 4 presents the resulting qualitative analysis. In Section 5, the main results are contextualised with past studies. Section 6 concludes and outlines future lines of research in this field.

2. Background

Dispersion, integration and specialisation are spatial dynamics that characterise metropolitan regions and imply increased travel distances and times (Banister, 2008). However, these have been complemented by other urban dynamics such as urban proximity, which relates to the use of the immediate urban environment by residents in order to meet daily needs (Calonge Reillo, 2017; Mateu et al., 2017; Schmid et al.,

* Corresponding author.
E-mail address: guillem.vich@uab.cat (G. Vich).

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2011). These dynamics are characterised by the agglomeration of activities and the intensive use of space, while facilitating human interaction, economic efficiency and social cohesion (Huriot, 1998), requiring certain morphological features such as urban compactness and density (Miralles-Guasch and Marquet, 2013). Thus, the recognition of this duality of urban dynamics (expansion and proximity) evidences the coexistence of different relational layers at a particular place of interaction in urban contexts (Massey, 1994), and the multiscale character of urban areas by linking the neighbourhood, the city and the metropolitan region (Atkinson et al., 2009).

Consequently, these spatial dynamics influence the utilised space by metropolitan residents in their everyday life. This daily space, also known as *activity space*, is structured by the locations with which people have direct contact on a daily basis (Horton and Reynolds, 1971) and has been a generally accepted measure of the geographic extent of the daily mobility of individuals (Gesler and Meade, 1988; Vich et al., 2017). However, the environmental factors influencing the extent of everyday life alone, such as physical distances between activities, might not fully explain spatial behaviour.

The anisotropic character of actual urban spaces means that spatial distances can be shaped by the combination of both objective and subjective factors, making perceptions, beliefs and preferences important determinants of spatial behaviour (Dumolard, 2011). For this reason, the built environment also acquires certain subjective qualities due to the perceptions of individuals related to, for example, what may be physically reachable (Horton and Reynolds, 1971). The mental configuration of the environment is the psychological process *"by which an individual acquires, codes, stores, recalls and decodes information about the relative locations and attributes of phenomena in his everyday spatial environment"* (Downs and Stea, 1973, p. 8), and can be represented through cognitive (or mental) maps.

This visual representation of cognitive structures is believed to internally delimit the external borders of people's activity space in their own minds (Greenberg Raanan and Shoval, 2014) and, therefore, influence spatial decisions of individuals over both the short and long term (Gärling, 1989; Golledge and Stimson, 1987; Lynch, 1960). Decisions on where to reside or work, and the locations, destinations for recreational activities, and how to travel between destinations also depend on the cognitive images of the surrounding environment of the individual (Downs and Stea, 1977). In an urban context, these spatial decisions may represent consequences for the territory, such as rising levels of energy consumption, air pollution and increasing investment in transport infrastructure, and loss of agricultural land and open space (Ewing et al., 2016).

The study of cognitive mapping within behavioural geography reached its heyday in the 1960s and 1970s. One of the main focal points was the exploration of how individuals built and organised spatial information in their own minds, in other words, how these mental structures evolve through learning (Downs and Stea, 1973). Cognitive maps were also used to understand the nature of preferential cognition with regards to the environment, with special mention to the work of Peter Gould and Rodney White in *Mental Maps* (1986, p. 15). Finally, a very successful body of research, in which the present study falls, analyses the processes of cognition of urban environments or urban imagery, with the remarkable contribution by Kevin Lynch (1960) of *The Image of the City*, highlighting the five elements forming cognitive spatial structures, which was later followed by Donald Appleyard (1970): pathways (streets, roads, trails…) along which people travel, edges or boundaries (walls, buildings, and shorelines), districts/neighbourhoods, meaning relatively large areas within cities with particular identity, focal points such as nodes and, finally, landmarks or identifiable objects serving as reference points.

In the late 1970s, the study of cognitive maps and environmental cognition was relegated to the field of geography due to the dominance of radical and humanistic approaches that considered such research as conceptually and methodologically flawed. Common criticism included the omission of economic and social conditions of individuals (Rieser, 1973) and their precognitive background emanating from the history, art, literature or religion, with which to understand people's behaviour (Tuan, 1976). In terms of methodology, methods often utilised in those days, such as ranking procedures or the sketching of cartographic maps, were regarded as being highly dependent on abilities to draw maps and upon education, hence, resulting in imperfect representations of spatial cognition (Blaut et al., 1970).

After years of relegation within geography, a rekindled interest for cognitive and behavioural methodologies, such as cognitive maps, has emerged due to two main reasons. Firstly, the combination of sociodemographic characteristics of the population (age, gender, etc.) with psychological processes to understand human behaviour, instead of solely focusing on the latter, is gaining acceptance in geography. The use and perception of large-scale environments by particular sociodemographic groups through their cognitive boundaries is now a common field of study (Argent, 2017; Walmsley and Lewis, 1993). An example of that would be to understand how children, seniors or women perceive and represent their residential neighbourhood. Recent evidence shows that cognitive boundaries and used spaces do not coincide with administrative limits of neighbourhoods, census tracts or residential buffers, hence, they prove to be more accurate representations of their geographic scale of their everyday life (Robinson and Oreskovic, 2013; Smith et al., 2010; Stewart et al., 2017; Veitch et al., 2008). This coincidence between perceived and used territories is also confirmed by Greenberg Raanan and Shoval (2014) who explore the cognitive maps and GPS tracks of adult women in the highly segregated city of Jerusalem. Another area of study that takes into account cognitive processes influencing human behaviour is transport and urban planning (Arentze and Timmermans, 2005; Gehrke and Clifton, 2015). In this line, Mondschein et al. (2010) and Minaei (2014) analysed the differences in mental representations of the cities of Los Angeles (USA) and London (UK) by commuters travelling using different transport modes. Although some classic research from the 1970s already analysed the legibility and desirability of predefined administrative limits of metropolitan regions through cognitive maps (Johnston, 1972; Pacione, 1977), no recent examples could be found which explore the cognitive representation of the experienced activity spaces and the influence of geographic scales in metropolitan regions.

Secondly, the development of sophisticated quantitative methodologies and the appearance of new technologies, such as Geographical Information Systems (GIS), also helped to maintain the interest in cognitive mapping (Gold, 2009). Furthermore, a geography-based approach in focusing on cognitive behaviour of particular groups within a population, such as children or the elderly, continued being active and also continued yielding vast amounts of research. Issues such as the development of environmental cognition and its pedagogic implications, the usage of territories and facilities, spatial preferences and perceptual constraints, among others, are still being studied and applied in policymaking (Argent, 2017). Advances in technology have also played a key role in allowing to collect, standardise and process large amounts of geographic information. Within GIS-derived applications, SoftGIS can be highlighted as containing useful tools for obtaining cognitive maps of individuals. Interactive on-line mapping applications, such as Google Maps© and Open Street Maps, allow the collection of spatial knowledge such as locations, routes and the delimitation of areas, while minimising memory bias (Chaix et al., 2012; Jarvis et al., 2017), and are normally included in surveys or interviews (Rantanen and Kahila, 2009). Whether used on computers, tablets or smartphones, these mapping applications are becoming a common tool of daily use among young people for wayfinding, since they provide 'up-to-date', scalable, 'more easily accessible' spatial information, standardising the drawing abilities of participants and, in consequence, they minimise the use of paper maps for research purposes (Leyshon et al., 2013). Existing studies have implemented this technique to explore, for instance, the barriers and facilitators of active transport among children (Broberg

et al., 2013) and this technique has also recently been used to explore children's spatial literacy (Jarvis et al., 2017). Nonetheless, only on few occasions has this method been used to explore the perception of boundaries of spatial behaviour (Stewart et al., 2015). Although cartographic maps have traditionally been common tools for extracting the cognitive images of individuals for their closest resemblance to familiar territories (Gärling et al., 1984), cognitive maps may not always have the same functions as cartographic maps, since they do not always share the same pictorial characteristics (Blaut et al., 1970). Even though representing cognitive maps with SoftGIS methodologies could be constrained by the fixed planar characteristics of cartographic maps, the intractability and flexibility of this technology make them a useful method to obtain the boundaries, locations, shapes or structures and the scale of cognitive maps.

3. Methodology

3.1. Study area

The present study is focused on the members of the university community of the UAB that travel daily to the suburban location of its campus in the Barcelona Metropolitan Region (RMB) (Fig. 1). The RMB is a region that is situated in the northeast of Spain and accounts for approximately 5 million inhabitants, 164 municipalities and covers an area of 3242 km^2, and can be divided into two functional rings. In this line, the RMB represents an optimal example of a dual model of urban growth, since it alternates between the compact and the sprawling city types (Marmolejo and Cerda Troncoso, 2017; Miralles-Guasch and Tulla-Pujol, 2012).

The UAB campus is an important economic and knowledge node for the territory (Miralles-Guasch, 2010). The suburban location of this campus makes this community an optimal example of the type of economically active population (18–64 years of age) whose daily mobility is constrained by an interurban commute that is generally carried out using motorised transport. The campus is located approximately 15 km from Barcelona city centre within the second ring, is connected with two major motorways (AP-7 and C-58) and includes three inner-campus train stations that link directly to Barcelona and other surrounding cities (Miralles-Guasch and Domene, 2010) (see Fig. 1).

3.2. Sample

Participants in the study were contacted through the database of respondents of the UAB's biannual Survey on Mobility Habits, carried out by the university in April–May 2015. These were selected through a process of purposive sampling following the selection criteria of: (1) Residing in the RMB, (2) Being a member of the UAB, (3) Commuting to the UAB campus using motorised transport (private vehicle or public transport). From a total of 33 people that were contacted, 28 commuters to the UAB campus were finally interviewed, since 3 commuted to the UAB by bicycle and 2 others lived outside of the RMB.

Information on their sociodemographic profiles, based on age and gender, were extracted from the survey, and the level of mixticity of their residential areas was used in order to classify the types of interviewees. Differences between monofunctional and mixed-used environments were extracted from the interviews, in which participants were asked to locate their everyday destinations (residence, work, groceries, socialising, and leisure). If more than 2 destinations were located at a walkable distance (15 min) from home, their residential area was considered as mixed-used, whereas, if only 1 or 2 destinations could be walked to, these areas were considered as monofunctional. When large-scale environments such as *neighbourhood, town* or *county* are mentioned in the text, they refer to the different levels of spatial scales perceived by participants.

These characteristics are summarised in Table 1. Participants commuted to the campus using public (14) or private transport (14). Their homes were located mostly in a mixed-used environment (21) that allowed walking to most daily destinations, although some other individuals lived in monofunctional and car-dependent residential areas (7). Regarding their sociodemographic characteristics, there were 15 male and 13 female participants and their ages comprised between 18–29 (9), 30–39 (10) and 40–64 (9) years. For confidentiality reasons, each participant was attributed with his/her initials using the Initials_Gender_Age (e.g. E_W_38) format.

3.3. Data collection

The aim was to detect the cognitive image of the activity space of a group of economically active adults that commute to a suburban location using motorised transport modes. Since the qualitative

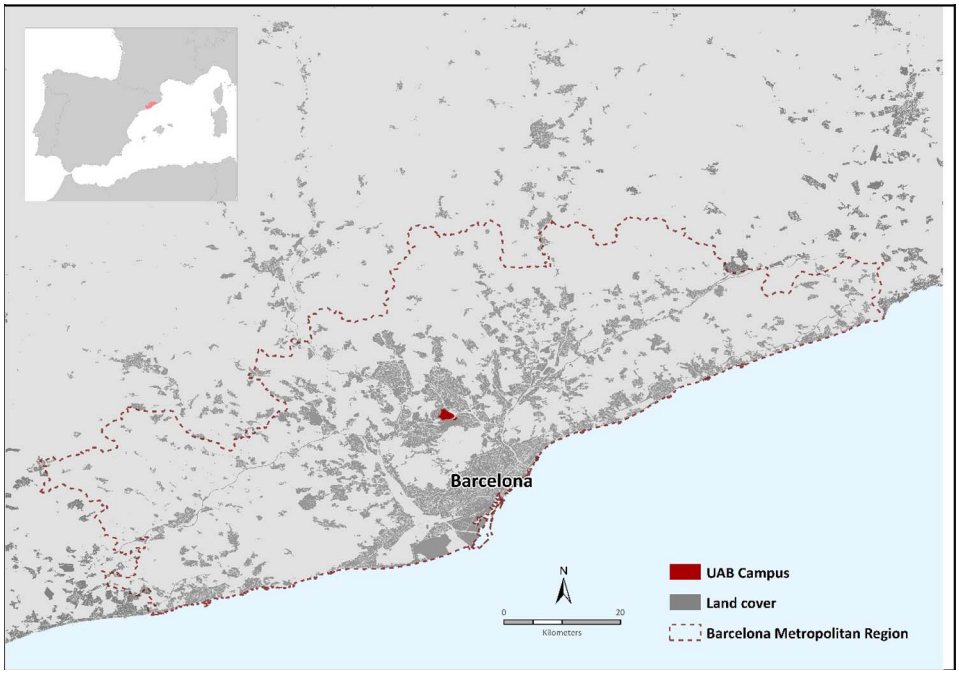


Fig. 1. The UAB campus in the Barcelona Metropolitan Region (RMB).
Source: own production.

Table 1
Main characteristics of the 28 interviewees.
Source: own production.

n	Code (Initial_Gender_Age)	Commuting mode	Level of land use mix	Commuting distance to the campus (km)
1	A_W_21	Public	Monofunctional	13,87
2	J_M_22	Public	Monofunctional	19,50
3	S_M_23	Public	Mixed use	9,11
4	D_M_24	Private	Monofunctional	22,70
5	X_M_24	Public	Mixed use	11,03
6	M_W_27	Private	Mixed use	9,25
7	M_W_28	Private	Monofunctional	46,04
8	V_W_28	Public	Mixed use	11,54
9	O_M_29	Public	Mixed use	3,38
10	C_W_31	Public	Mixed use	10,19
11	J_W_32	Private	Monofunctional	49,29
12	A_M_33	Public	Mixed use	10,60
13	A_M_34	Public	Mixed use	48,13
14	D_M_36	Private	Monofunctional	43,25
15	A_M_37	Public	Mixed use	5,01
16	I_M_38	Private	Mixed use	9,69
17	G_W_39	Private	Mixed use	7,93
18	R_M_39	Public	Mixed use	10,13
19	J_M_39	Private	Mixed use	11,55
20	F_M_42	Public	Mixed use	2,34
21	M_W_42	Private	Monofunctional	2,27
22	F_M_44	Public	Mixed use	9,97
23	B_W_45	Private	Mixed use	8,08
24	M_M_47	Public	Mixed use	13,45
25	J_M_48	Private	Monofunctional	20,28
26	P_W_50	Private	Mixed use	8,32
27	T_W_56	Private/ Public	Mixed use	2,13
28	J_M_63	Private	Mixed use	10,23

methodology applied in this work could not statistically generalise its results, the main aim was to analytically generalise the cognitive image and discourses that were detected throughout the experiment. The mapping exercises and interviews were mostly held in December 2015 within the Department of Geography in order to secure the optimal technology conditions (computer and Internet connection), although, on several occasions interviewers displaced themselves to the work place of the interviewees when requested.

Data were collected during 30–45 min through two map-sketching exercises combined with a series of interviews to obtain 3 types of information: a sketch map, an activity map and an oral map. Firstly, in order to obtain a sketch map, participants were asked to recall and refresh the main everyday activities via two questions: *"What activities do you carry out in an average working week? Where are these located?"*. Then, participants were asked to draw a geometric polygon, the area of which would include their weekly activities using the shape-making tool provided by Google Maps©. The aim was to obtain their cognitive map, in other words, to measure how they perceive the boundaries of the spatial extension of their daily activities. Secondly, for obtaining the activity map, participants were asked to place on the same map a closed list of everyday activities they were provided (residence, workplace, groceries, leisure, social destinations, etc.), using the marker tool from Google Maps©. The purpose of this exercise was to delve into the reason for choosing the location of these activities and to detect which activities were not considered or were forgotten when delimiting the boundaries of their activity space. Then, these two maps were later tested against the spatial perception obtained by using the questions from the interviews, in order to gather further information that was not accessible from cartographic maps (Blaut et al., 1970). After the two first exercises, a series of open questions were asked to qualitatively assess the information previously provided and, therefore, to delve into the cognitive image of their everyday environment. Interviewees had to give their opinion during 10 min on the following topics: the reasons behind the shape of their sketch maps, the assessment of the closeness or farness of daily activities from home (in time units) and the reasons for choosing their daily destinations. After recording all the interviews, a thematic analysis was performed using the results. Different themes and stratified groups were identified after reviewing the obtained maps and transcript interviews and were assigned to the objectives of the study. The analysis in this study does not try to generalise, but rather aims at situating the discourses and opinions in this specific context.

4. Results

4.1. The perception of the activity space at one single scale

Most metropolitan residents in this study identify their activity space with the whole metropolitan area, since their daily activities are spread throughout different parts of this territory. This spatial dispersion of activities was represented through a cognitive image of activity spaces as polygons at one scale, the metropolitan scale. However, this single scale space was also represented either as a *unit* or as a group of *fragmented* entities. These two types of representation of the everyday spatial extent have been manifested through the exploration of the different methodologies used in the study.

As Table 2 shows, the *sketch maps* of participants drawing a single figure acquired two different shapes. This single figure was either identified as the generalisation of the everyday space utilised (see sketch from participant D_M_24 in Fig. 2) or as a space following the road infrastructure used in their commute (see sketch from participant D_M_36 in Fig. 2). Regarding the exact position of daily destinations from their *activities maps* (UAB campus, home, shops, leisure, social and personal destinations), these were placed at the vertices of the drawings. Furthermore, the *oral maps* corroborated the same cognitive image of a territory perceived as a unit and including their daily activities across different parts of the Barcelona Metropolitan Region:

> D_M_24: *My activities are all very scattered across the map, but for me it is a unit.*

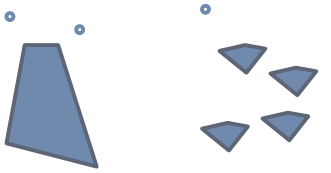
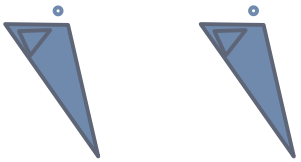
This representation of the activity space at a metropolitan scale and drawn as a single territory is also related to explanatory factors such as the use of private transport, since obtained cognitive maps identified the daily routes utilised through roads and motorways, being more evident in a sketch from participant D_M_36 rather than from participant D_M_24. It is noteworthy that all of these residents lived in monofunctional residential areas, as seen in Table 1, in which there is a lack of many everyday services (shops, leisure, social activities, etc.) and residents are forced to drive a motorised vehicle in order to reach all of their daily destinations, hence, enlarging the boundaries of their daily perceived utilised space outside their residential areas:

> J_M_48*: Our village is well located since we have the campus and all daily amenities within 20–30 min driving distance to the neighbouring towns.*

However, *sketch maps* and activities maps did not always coincide with the orally-described cognitive image, since a contradiction between the visual and the oral description was evidenced among some participants. Although their activity space is represented as a unit in the *sketch map* and their daily activities were located at the vertices of these figures spread across the territory, these individuals declared experiencing a distinction between the space around the UAB campus and the territory surrounding the rest of their activities:

> D_M_36*: The UAB is far from home and even more so if I get into traffic jams. I see it as something separate. In my everyday life I distribute my activities around the county, but not in my own town.*

Table 2
Different perceived scales and shapes of activity spaces, across three cognitive map methods.
Source: Own production.

Results	Scale	Metropolitan		Metropolitan + Neighbourhood	
	Shape	Unit	Fragmented	Overlaid	
Method	Sketch map				
	Activities map				
	Oral map				
Explanatory factor of cognitive differences		Transport mode Land use mix	Distance between functions	Transport mode Land use mix	Distance between functions

These cognitive maps, expressed as the sum of fragmented territories, were also detected in the *sketch maps* (see sketch from participant M_W_27 in Fig. 2) of other participants. In them, a group of drawn areas included the different daily destinations, evidencing a representation of the functional separation of the RMB. In this case, the locations of the *activities maps* were placed inside each of the multiple independent spaces. Their comments in their *oral maps* highlighted the perception of space surrounding their home and daily activities as more familiar and unconnected from the space surrounding the UAB campus:

> M_M_44: *For me, home and work are two separate spaces. Between the campus and my home there is an empty space.*

This perception of the region as a fragmented territory can be explained by the increased distances due to expansive and functional segregation developments, since participants with this type of cognitive image live further away from the campus than other participants.

4.2. The perception of the activity space at two different scales

The cognitive image of activity spaces of residents in this metropolitan region showed other particularities. Some participants experienced the influence of another spatial dynamic within the overall utilised space at a metropolitan scale, which is spatial proximity. This resulted in the perception a duality of territorial scales including, simultaneously, distant (metropolitan) and close (neighbourhood) spaces from the place of residence. However, these different spatial dimensions of their everyday life could not be detected by all of the methodologies used in this study.

As Fig. 3 shows, while the obtained *sketch maps* highlight the shape

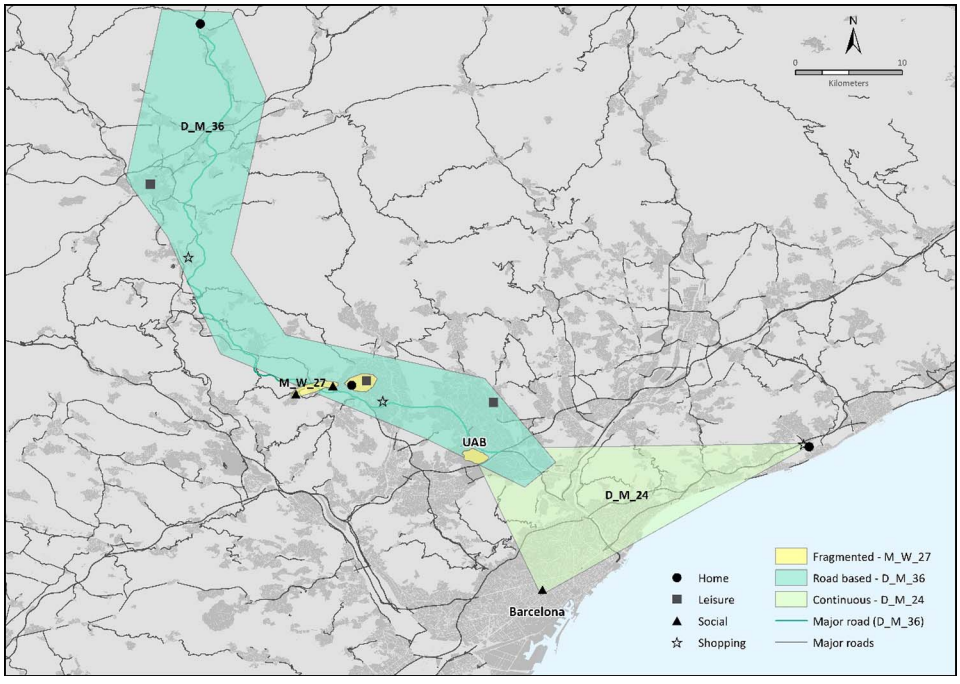


Fig. 2. Perceived activity spaces at one single scale.
Source: Own production.

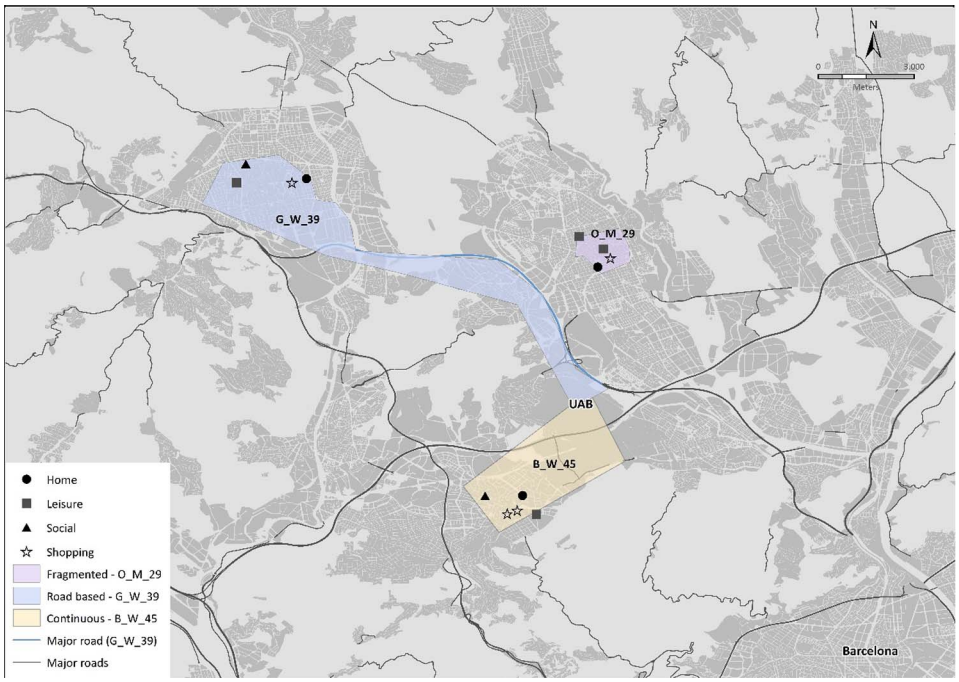


Fig. 3. Perceived activity space at two different scales. Source: Own production.

of one single figure at a metropolitan scale, the *activities maps* and *oral maps* contradict the initial sketches, signalling a clear distribution of daily destinations at both metropolitan and neighbourhood levels. These locations were clustered around their place of residence, normally at a walkable distance, but also placed the location of the UAB at a further distance. See the sketch from participant B_W_45 in Fig. 3:

> B_W_45*: Apart from my workplace at the campus, I have most of my daily activities within walking distance. I really like it because I get very stressed when riding my motorbike to work every day.*

The transport infrastructure also proved to influence on the perception of the spatial scale of everyday activities on residents experiencing this duality of scales. In this case, the obtained *sketch maps*, represented as one single polygon, also imply the representation of both the utilised road and railways infrastructures. Moreover, in some cases, the areas surrounding the residence and the UAB campus are clearly identifiable, but are connected through the transport infrastructure (see the sketch from participant G_W_39 in Fig. 3):

> G_W_39*: My daily activity is characterised by my main trip to and from the UAB and the rest is spread locally around my hometown.*

The distance between place of work and residence was also related to differences in the spatial perception among individuals when experiencing a duality of scales of everyday life. Among those living further away from the UAB campus, the space referring to the neighbourhood was highlighted as being more important for them to the detriment of the space implied by the commute to the UAB campus (see the sketch from participant O_M_29 in Fig. 3). It was at a later stage, when locating daily destinations and the oral description of their cognitive image, that they admitted the perception of these two territorial scales:

> O_M_29*: Yes, the campus is there, i.e. outside of Barcelona, but the most important part for me is my life in Barcelona.*

Finally, the perception of this duality of territorial scales in their activity spaces has been specifically detected among residents in urban areas that are characterised by a mixture of land uses. The morphology of these areas, allowing the access to most of their daily destinations on foot, has proven to be a determining factor of their cognitive image, implying a differentiation between the spaces surrounding residential areas from the spaces that include the UAB campus.

To summarise the results, they show how the everyday life of these participants fully occurs within the territory of the RMB, although the perception of this metropolitan space varies across participants and methods utilised to capture the cognitive image of activity spaces. As Table 2 shows, the perception of the scale can be divided into two levels, one identified with the whole of the metropolis, and another that superimposes the neighbourhood scale onto the metropolis. The shapes of extracted cognitive maps relate to a territory that is understood as a unit, as a fragmentation or as multiple overlaid spaces. These particularities and nuances have been detected differently across the utilised methods to obtain the cognitive maps of participants: sketch maps, activities maps and oral maps. Finally, the characteristics of the residential area, the commuting distance and utilised transport mode of individuals have proven to influence on their cognitive maps.

5. Discussion

The main finding of this study is the corroboration of relational geography and planning postulates by which spatial scales should not be understood as nested hierarchies, but rather as extensions in space (and time) connecting many discontinuous sites in different networks (Healey, 2004; Massey, 1994). Within this conceptualisation, social relationships can be shaped in spatial *'warps'* and *'folds'* (Amin and Thrift, 2002) or *'bits'* (Mitchell, 1995), as was detected in the results of the study, with participants representing their cognitive maps at different scales (i.e. metropolitan, proximity or dual) and shapes (i.e. single unit, overlaid spaces and fragmented territories). Moreover, this study adds to the body of research within behavioural geography and cognitive mapping by exploring the imagery and legibility of urban environments as initiated by Lynch (1960), proving that cognitive processes can allow particular groups of population, in this case urban commuters, to perceive the same geographic context in different ways (Marquet and Miralles-Guasch, 2014; Matthews and Yang, 2013).

The first evidence of the results shows that residents living in this region perceive the spatial distribution of activities at a metropolitan scale, since participants' activities are spread across the territory, as

demonstrated by sketched and oral cognitive maps. A clear example of this can be seen in those cognitive maps which represent, in the terminology of Lynch, the boundaries of their territory as a single-scale spatial continuum which includes their place of residence, the UAB campus and the rest of their daily activities at the edges. This proves how the increasing the distance between activities in metropolitan contexts can be perceived and represented in cognitive maps as large extent territories. This coincides with studies that objective measure the scale of activity spaces in order to explore the effects of suburbanisation and urban expansion processes in everyday life (Buliung and Kanaroglou, 2006; Vich et al., 2017). This type of perception, expressed as a spatial continuum, could represent cognitive images of the whole territory as an easily reachable space, especially through the use of private vehicles. In fact, previous research has proven how access to private vehicles is associated with perceiving job opportunities in less spatially constrained ways, since these can be searched for in larger geographical areas with respect to work (Holzer and Reaser, 2000; Stoll, 1999). The consequent spatial behaviour derived from this kind of perception often creates well known externalities such as traffic congestion, increased energy consumption or air pollution (Ewing et al., 2016).

Some cognitive images obtained in this study represent small-scale boundaries within or attached to the larger-scale activity space that include non-work daily destinations, forming what previous authors describe as *'folds'* (Amin and Thrift, 2002), which can be explained by the dual model of urban development of the RMB, characterised by multiple territorial scales (Marmolejo and Cerda Troncoso, 2017; Miralles-Guasch and Tulla-Pujol, 2012). This differentiation of regions within cognitive maps is also confirmed by other participants representing their activity spaces as a fragmented territory, not overlaid, in which different parts correspond to different daily destinations (residence, work, leisure, etc.), in other words, what relational geographers describe as *'bits'* (Mitchell, 1995). This functional regionalising of cognitive territories as overlaid or fragmented can also be linked with the concept of *anchor points,* previously introduced by behavioural geographers, by which nodes or reference points, such as workplaces or residences, anchor differentiated regions in the cognitive maps in any given environment (Couclelis et al., 1987). Recent studies confirm these findings from Robinson and Oreskovic (2013) with adolescents also perceiving their neighbourhood limits as multiple non-contiguous areas, and also from Minaei (2014) with the finding of an association between the cognitive regionalisation of the territory and the daily use of GPS navigation services in London.

Within regionalised cognitive images of territories, local environments have proven to acquire high relevance among many participants. This can be explained by a common attachment of residents in metropolitan areas to their neighbourhood and a preference for its environmental setting (Johnston, 1972; Lovejoy et al., 2010). This preference for local environments might also have consequences for spatial behaviour, being potentially beneficial in terms of transport-related externalities, especially if the urban morphology of preferred residential areas allows the creation of urban proximity dynamics.

Another idea appearing in this study is the importance of the pathways connecting origins, nodes and destinations. Among many participants in this study, the utilised transport infrastructure (roads and railways) was made clearly identifiable in their perceived image of activity spaces. This is particularly relevant since this group of commuters uses the same pathway on a daily basis to reach the university campus and, therefore, it becomes an important structural part of their cognitive image of the real world that connects their everyday destinations. Lynch (1960) and Appleyard (1970) also found that some people represent cognitive maps as complete road systems, probably due to the recurrence of the journey and familiarity with the map of the city. More recently, Minaei (2014) also found a higher positive correlation between car usage and the structuring of cognitive maps via the roads of a city.

In terms of methodology, this study delves into the quest for optimal measurements of the geographical scale at which characteristics of built environment influence individuals (Gehrke and Clifton, 2015; Matthews and Yang, 2013). Cognitive maps prove to be more realistic representations of the utilised space compared to the administrative limits of neighbourhoods or census tracts, corroborating the previous literature which notes that everyday life also occurs in locations away from residential areas (Inagami et al., 2007; Stewart et al., 2015; Vallée et al., 2014). Moreover, SoftGIS applications in combination with oral descriptions of cognitive maps have proven to describe the cognitive image of the real world more accurately, since the sole use of two-dimensional boundaries from cartographic maps would fail to represent multiple and overlaid spatial scales of cognitive maps.

6. Conclusions

This study has explored the influence of the geographical scale on the cognitive images of the activity spaces of individuals residing in a large-scale territory that is characterised by multiple spatial dynamics. In order to achieve this, a sample of economically-active residents of the Barcelona Metropolitan Region with a constraining interurban commute to a suburban location was selected. The cognitive images of their activity space were obtained and analysed by using two SoftGIS map-sketching exercises and their oral descriptions from semi-structured interviews.

The present work has confirmed that a single territory can be perceived differently and that the diversity of functions and the mode of transport influence this perception. Our study finds that functional segregation leads to a perception of a metropolitan territory as broadly reachable by means of motorised transport, although residents experiencing proximity dynamics also perceive the smaller-scale local environment within larger spaces, which are usually preferred.

The utilisation of cognitive maps to explore the perception of large-scale environments adds to the re-born focus on cognitive-behavioural approaches in geography (Gold, 2009). The use of three different techniques to capture the cognitive maps of participants has proven the importance of the election of method. In this case, SoftGIS tools have been useful to obtain the boundaries, location, shape or structure, size or scale of perceived activity space, but it has been the inclusion of oral representations of cognitive images that allow to obtain the perception of different urban spatial dynamics in play at a particular place, that the simple drawing of cognitive boundaries would not have been able to detect.

Finally, we have deepened knowledge of the cognitive image of the real world which provides insight for urban planning and transportation policies regarding urban accessibility challenges. The perception of a regionalised territory and preference for residential areas, as shown in this study, can encourage planners to enforce proximity dynamics while minimising transport-related externalities (Ewing et al., 2016). Moreover, since cognitive maps inform on how places, travelling distances or transport infrastructures are perceived; this knowledge provides a basic foundation for policymakers to understand spatial decisions, such as where to reside, where to look for job opportunities or leisure activities and how to travel between destinations (Delclòs-Alió and Miralles-Guasch, 2017; Mondschein et al., 2010). Therefore, this study challenges the utility maximisation preconception of physical distance as the main determinant of spatial behaviour.

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