Drawing, Measurement and Movement. The Representation of Space in Urban Maps (an Interdisciplinary Analysis)

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Abstract

Urban maps represent the simplified drawing of a complex world (urban space) where material and immaterial phenomena, problems and solutions coexist; they are a tool used by individuals to perceive and act in space.
In our current socio-urban context these representations are particularly interesting, above all due to the complexity of contemporary metropolises. Maps accompany us in our complex "urban" life more as maps of complexity than maps of the city.
The contribution tackles this issue from the point of view of representation and the individual. It illustrates an interdisciplinary study that analyses the complexity of represented space, i.e., of the urban (such as spatial and social concentration, anthropological expression and system) and the problems linked to the complexity of its representation (i.e., the complexity of urban maps) which is solved by simplexity. It also analyses man's capacity to act and move in real space (linked to the vital impulses of the organism, propriocetion and kinesthesia and the wonderful and extremely plastic ability to move in the environment) and thus the possibility of an individual to act and move in space through representation – linking his action to represented space and exploiting his brain's ability to foresee movement in the drawing, i.e., in the map.

Keywords: urban maps, urban drawing, urban space, movement in space, perception and action.

Introduction. Space, representation, individual, action

From the point of view of representation, urban maps represent the drawing of a simplified complex world (urban space) where material and immaterial phenomena, problems and solutions coexist.
From the point of view of the individual, maps are a tool with which to perceive and act in space.
If these two viewpoints are broken down into their essential terms – space, representation, the individual, perception and action (movement) – I could end my introduction right here, with these two or three lines. Without wanting to be or able to be exhaustive, I could add that I will try to tackle the subject of maps from both points of view, by (literally) combining them in an interdisciplinary study on the representation of space and the relationship between representation, space and the individual in urban maps.
However I will continue this introduction with short but necessary considerations about some of the concepts related to the relationship between the individual, space and representation; these concepts are the cornerstone of this study justifying an interdisciplinary approach.

Space
First of all, I need to emphasise the adjective of space, i.e., "urban"; I will try to show how both representation and the individual have to deal with its complexity.

Action in real space
According to Alain Berthoz, professor of physiology of perception and action at the Collège de France, our brain projects our own perceptions, hypotheses and interpretations on the world so as to anticipate the consequences of an action [Berthoz 2011, p. XI].
This happens everyday and applies to all our actions, even when we have to act in the space of the city. When we move, we perceive, measure and interpret it, creating the right conditions for each of our actions and each movement.
Through action we bind ourselves to space. We somehow appropriate it. Berthoz writes that action is an immediate data of consciousness, and that anchoring notions of space in an action eliminates the gap separating abstraction from reality [Berthoz 2011, p. 131].
Man's ability to act in space is behind this individual-space-action triangulation (an individual moving in space). As stated by Carmela Morabito, a historian of psychology and cognitive neurosciences, the motor paradigm defines a new image of the organism developed on action, "and also produces a new image of man whose species-specificity is not to be found only in reason, consciousness and willpower, as it has generally been from Descartes onwards, i.e., in what has been defined as 'superior cognitive functions', but instead naturalistically identified – first and foremost – in the vital impulses of the organism, in propriocetion, in kinesthesia, in the wonderful and extremely plastic ability to move effectively in an environment" [Morabito 2020, p. 16].
So, individuals move in space based on how they perceive themselves: through their own propriocetion they perceive, measure and adapt their bodies in relation to space. Sherrington called it "our secret sense, our sixth sense", "that continuous but unconscious sensory flow from the moveable parts of our body (muscles, tendons, joints) by which their position and tone and motion are continually monitored and adjusted, but in a way which is hidden from us because it is automatic and unconscious" [Sherrington 1906, pp. 336-344; Sacks 1985].
Even if we perceive and measure space using Marr's visual mechanism [Marr 1982], without this sixth sense individuals would not be able to move and act in space. Oliver Sacks describes one of his patients who did not have this sixth sense as "disembodied... condemned to live in an indescribable, unimaginable realm-though 'non-realm', 'nothingness' might be better words for it" [Sacks 1985].
Individuals use action and behaviour in the space of the city to establish relationships with the outside world and other individuals, while the brain codifies, elaborates and preserves the emotionally-developed data linked to memories, circumstances and spatiality. When an individual walks down a street he is able to relate it to another street or place; he measures it and gradually recognises its depth, width, deviations and then the structures, colours and heights around it. Using unique procedures and coding systems that are specific to every individual, he establishes a relationship between the places and full and empty spaces in the city. This is how he thinks of space; he assigns the city measurements, proportions and relationships he did not actually detect. A sort of unconscious urban drawing.

Action in represented space
One of the main functions of the brain is to foresee. It is a machine that anticipates and simulates reality before acting "in the extremely short space of time preceding action" [Berthoz 2011, p. 173]. "Like a biological machine [...] the brain is considered as a sort of 'anticipator', foreseeing the motor possibilities of an organism in an environment" [Morabito 2020, p. 14].
In this respect, an individual's action in real space can be anticipated in represented space thanks to a prevision (simulation) of the action his brain performs in the representation. This happens when we use a map, i.e., a drawing – simplex and useful [Berthoz 2011].
This not all. The brain goes further: "using our mental processes it does not simulate only tangible routes or the map of a city. It also divides space in many different ways depending on our affiliation to multiple communities" [Berthoz 2011, p. 141]. In other words, the brain simultaneously selects the physical and social extension of space. In fact, space is a house, a city, a village, but also a region, a country, a continent [Berthoz 2011].
"Space is not only what we cross in a labyrinth, a garden, when we travel 'around our room' or in our city" [Berthoz 2011, p. 141].
It is something that is increasingly complex, even to represent.

The "urban" and its representation

The study and drafting of city maps as complex systems representing the "urban" and communicating all its data primarily require the involvement and interpretation of the characteristics and phenomena that make up the urban itself.
As stated by the anthropologist Ariel Gravano, we can consider the urban as the phenomenon of spatial concentration; its expression par excellence is the city made up of an ensemble of physical, spatial and social infrastructures [Gravano 2016, p. 51].
This ensemble identifies and physically represents the city; the phenomena that broaden the urban concept are linked to the city. Gravano writes that in fact the urban appears to be a problem when talking, for example, about the conditions of the traffic, houses and service while it appears as an urban crisis when these problems are grouped together and characterise a typical lifestyle adopted in cities [Gravano 2016, p. 50]. In addition, he states that the urban emerges as a demand when there is a lack of the basic urban infrastructures that guarantee a "dignified" life while instead it appears as a reform because the urban is a spatial form designed and created as a renovation, as an alteration compared to the non-urban landscape or previous urban landscape; it appears as utopia, as an ideal, when one imagines or designs the desired city, the city one wants to build and live in [Gravano 2016, pp. 50, 51].
So the urban appears as a complex ensemble of spatial and social characteristics and phenomena, continually renewed by welcoming innovations and stratifying transformations and information.
On the other hand, Gravano also states that throughout history the city has always embodied progress and a break with the natural, with what is not artificial, with what is given, and what is prescribed [Gravano 2016, p. 51]. According to Lewis Mumford, the city is the point of maximum concentration for the power and culture of a community; it is the form and symbol of an integrated social relationship, where human experience is transformed into visible signs, symbols, patterns of conduct, systems of order [Mumford 1970]. Paul Ricoeur states it is a place where man perceives change as a human project [Ricoeur 1978, pp. 123-136].
Gravano also writes that in the twenty-first century the city is like a problem that can be solved by several different disciplines [Gravano 2016, p. 50], where the guiding principle, as stated by Berthoz, is complexity [Berthoz 2011, p. VII] and its representation in a map follows and illustrates the transformations of its form as well as urban complexity.

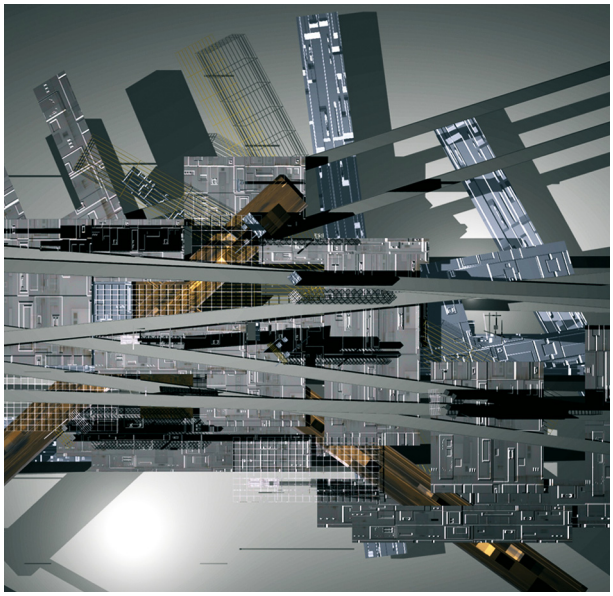

Fig. 1. Rosario Marrocco, Urban Map, 2020. Mixed technique (60 x 40 cm).

Representing urban complexity

Managing and representing the complexity of urban space as well as elaborating and communicating the increasing amount of data contained in the city means it is crucial to achieve simplified representation. Simplification does not involve eliminating or reducing the data, but maintaining its visibility and making its complexity decipherable. Graphic and symbolic systems are normally used in urban maps to represent this complexity.
As a result, maps are a figurative mix of complexity and simplicity, of simple representation and the complexity of (urban) space.

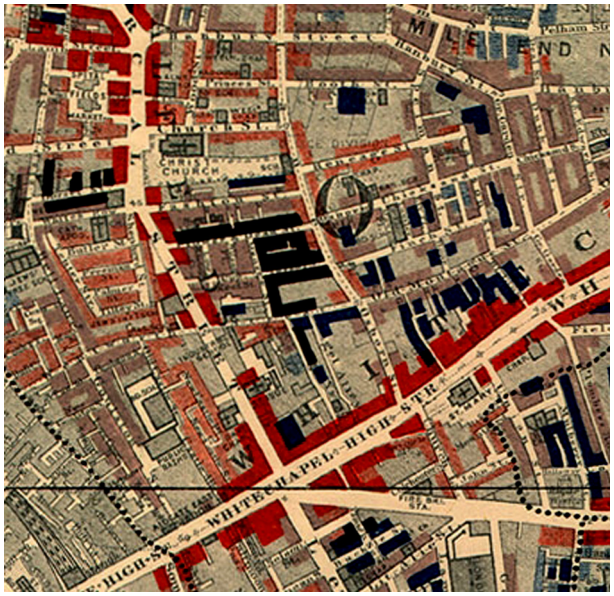

Fig. 2. Charles Booth, Maps of London Poverty, 1889 (Booth 1889).

Before discussing representation I will briefly focus on urban complexity.
Generally speaking "complexity is, by its very nature, difficult to define [...] Nor does a univocal method exist to measure its complexity" [Bertuglia, Vaio 2019, p. 21]. As stated by Philip Warren Anderson, Nobel Prize for Physics, it is present in those "systems [like cities] that are so big and intricate they display an autonomous behaviour" [Anderson 2011, pp. 364, 365]. The complexity of a system, considered as "an organic aggregate structured by interacting parts" [1], is perceived when its component elements are not only side by side – i.e., not as a simple sum of single parts [Bertuglia, Vaio 2019, p. 21] – but interact.
This occurs in the urban system where complexity is perceived by the quantity and close interrelation (also formal and functional) of its elements, which can either be physical-spatial (buildings, roads, networks, etc.) or social (citizens) [Bertuglia, Vaio 2019, pp. 25, 26].
Every element contains and expresses its own complexity that interacts with the complexities of other elements, thereby determining the complexity of the urban system and city system.
By representing each element (either physical-spatial or social) it is possible to represent urban complexity, acknowledging in each element the interaction it generates with the other elements in the system. This also occurs in urban maps where a single element – nearly always physical-spatial – represents the complexity of urban space.
Let's now go back to representation. For the purposes of this study we can establish a classification [2] of the physical-spatial elements of the city system, a thematisation generally used in urban maps:
a) urban drawing, places and services;
b) transportation;
c) commercial and tourist structures.
A physical-spatial element of the city is represented in each of the maps analysed below (figs. 3-10). The cities are located in Europe, Asia, Latin America, North America and Oceania.
More specifically: as regards transportation (b) figures 3-5 show the maps of the current subway systems in Tokyo, New York, Berlin and Paris (figs. 3-5) and figure 6 presents a sixties' map of the railway networks in the Province of Buenos Aires [3]. As regards commercial and tourist structures (c), two maps show the city of Sydney (the *Map Walking Tours*, fig. 7) and Tokyo (the *Akihabara Map Electric Town, Shop Guide*, fig. 8). Overall maps of urban drawing, places and services (a) are instead illustrated in the maps of two small cities in Argentina: Olavarría and Salta (figs. 9-10) [4].
The maps of the subways in Tokyo, New York, Berlin and Paris (figs. 3-5) provide the information people need to move around and have clearly been drafted for this purpose. But they also represent the contemporary complexity of big metropolises, in this case caused by the density of the above and below ground transportation networks.
The city's production level is represented in the network by the quantity of lines, both above and below ground, that ensure the movement of people, goods and services and enable work, trade, tourism and exchanges which in turn increase competitiveness and fuel the fabric of the urban economy.

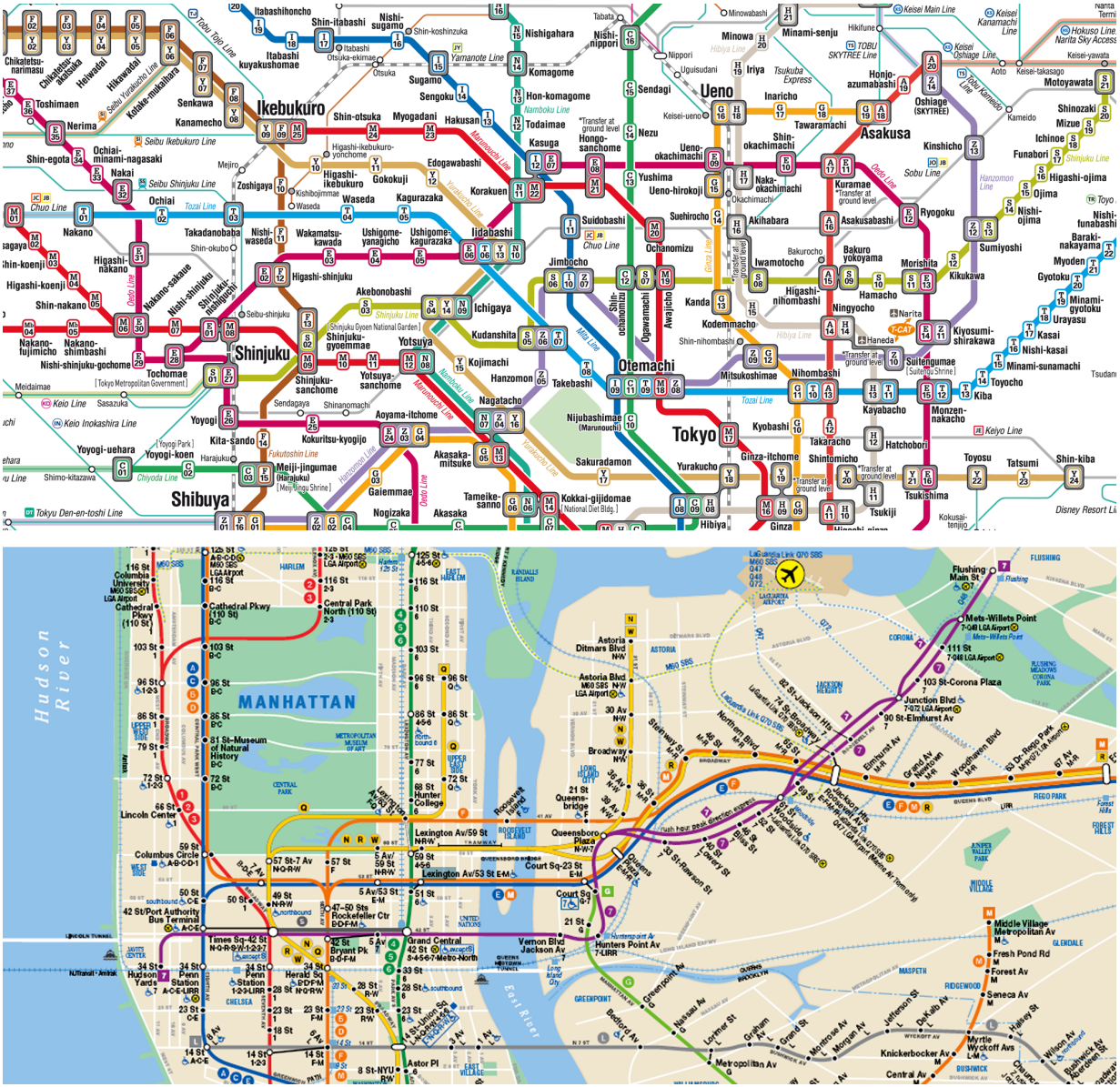

Fig. 3. (above) Tokyo Subway Route Map (06/2020). Source: Tokyo Metro. Bureau of Transportation, Tokyo Metropolitan Government. (below) New York Subway Map 2020 (11/2020). Source: MTA, Metropolitan Transportation Authority.

Fig. 4. BGV. S-Bahn / U-Bahn Berlin (10/2020). Source: Berliner Verkehrsbetriebe (BGV).

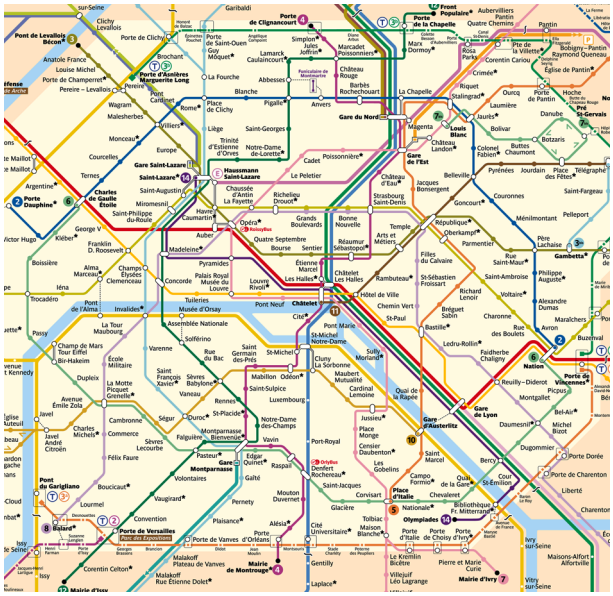

Fig. 5. Paris Metro-RER-T- Map (10/2019). Source: RATP (Régie Autonome des Transports Parisiens).

The network also shows part of the spatial and social phenomena of the urban, for example: the size of the urban area that usually corresponds to the range of the subway lines (fig. 4), or the concentration of the urban fabric and therefore of the demographic density which generally corresponds to the concentration of the lines and stations (figs. 3-5).
Likewise, the territorial networks represent the production capacity of a region, province or country. The map of the railway lines in the Province of Buenos Aires (fig. 6) represents the growth, radication and connection of the urban in the territory, i.e., the complexity of the relationship between the city and the territory.
Some maps use urban complexity to represent anthropological complexity. In other words, in the real world social elements interact so intensely with physical and spatial elements they ultimately configure anthropological phenomena, also reflected in the representation. In these cases the map is also an anthropological image, a map of possible actions not only in space, but also in the society that lives in and creates that space.
The map of *Akihabara*, a district in Tokyo (fig. 8), is one example; the spatial information regarding trade, tourism and services illustrated in the graphic grid showing the urban fabric reflects lifestyles, consumption patterns and human relationships.
Another important example of representation of anthropological and urban complexity dates to the late nineteenth century when the sociologist Charles Booth used representation to illustrate the socio-economic and urban complexity of London.
According to Booth, it could easily solve a complex phenomenon such as poverty. The sociologist also transferred the problem of destitution into space and tasked the city and its districts to represent the phenomenon, "suggesting that what an individual called 'home' [could] influence not only his standard of living, but also his behaviour" [Garfield 2016, p. 221].
The poverty map (fig. 2) Booth published in 1889 [5] was an attempt to provide an answer to three com-

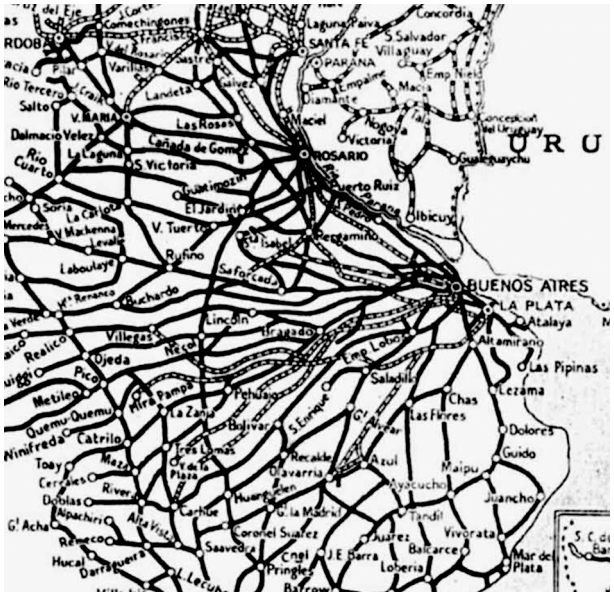

Fig. 6. The Argentina Railway Network, c. 1960. Source: Uncertain.

Fig. 7. Map of Sydney, Walking Tours. Sydney, 2017. Map, property of the author.

plexities: social poverty; places of poverty; representation (and diffusion) of the phenomenon. It was a very controversial answer, even ethically, because rather than just identifying and representing poor areas, he assigned specific social classes (from semi-criminal to the upper classes) to the urban fabric (using colours). This turned the poverty map into a map focusing on poverty. A sort of socio-urban graphic-alert.
The "simplicity" with which Booth mapped London not only dealt with, but also clashed with a complexity that obviously did not originate and exist only in space (since space is the effect of poverty and not the cause) and could not be tackled using this conceptual approach.
The map illustrated the historical context of a city that tried to pinpoint the reasons and methods of a transformation in its drawn representation; in fact it is cited as a "historical" example of the use of representation as an approach to socio-economic and urban complexity.
Now I'll focus on another example of complexity: the maps by Olavarría and Salta (figs. 9, 10).

Considering the origin, location and size of the two cities, it's certainly difficult to imagine urban complexity. In fact, spatial simplicity is reflected in the representation, in the two maps portraying the urban drawing with its places of historical interest and services.
Nevertheless, it is ontologically interesting due to the simplicity of the urban drawing and orthogonal grid which, quite apart from its history, recalls a possible method with which to transform the Earth, again using drawing present in every map. From the small to large human scale.
Regarding this issue I'll briefly comment on the second plan of Buenos Aires made by Juan de Garay in 1583 (fig. 11). A simple division of land; a map of the lots assigned to the founders of the city. A map showing the human radication that triggered the change mentioned by Gravano: from a landscape to an urban landscape [Gravano 2016, pp. 50, 51] based on the relationship between man, space and representation.

Fig. 8. Akihabara Map Electric Town. Shop Guide 2019. Akihabara, Tokyo Japan. Map, property of the author. (above) Detail of the area around the JR Akihabara Station.

The complexity of representation. Simplexity

After focusing on maps as representations of urban complexity, I will now concentrate on the complexity of representation.
Two complexities are evident when studying the maps: one relating to space and the other relating to representation, i.e., relating to the way in which space is represented in a map.
First off, in the previous paragraph a reader may have already recognised the representation of space as something simple rather than complex.
But now we're focusing on another issue.
Earlier I said that the complexity of urban space is "managed" in maps by the simplicity of its representation. A simplicity which, by deciphering urban complexity, allows an individual to understand its complexity and "use it", i.e., use the map. This use can be defined as the first level of use of a map.
Now I will analyse a second, more in-depth psychological use that allows individuals to perceive space and interpret it, linking their action to the represented space.
In this second level of use, the complexity with which space is represented determines a different involvement of the individual; this involvement increases gradually when simplicity is superimposed on complexity until it becomes a "complicated simplicity", in other words a simplexity [Berthoz 2011, p. XI].
The criteria that can be adopted is still that of simplicity, focusing on a complexity-simplicity crasis, this time based entirely on representation.
The result of this (second) crasis is a representation that can be defined as "simplex", reminiscent of Alain Berthoz's theory of simplexity [2011].
Berthoz writes that simplexity is therefore a decipherable complexity, i.e., it is *complicated simplicity* because it is based on a rich "combination of simple rules" and that this neologism indicates one of the most amazing inventions of living organisms, applicable at various levels of human activity, from the molecule to thought, from the individual to intersubjectivity, and on to consciousness and love [Berthoz 2011, pp. VII, XI].
I would like to point out that I consider simplexity as a theoretical paradigm; the multiple references to space and architecture made by Berthoz himself [Berthoz 2011, pp. 151-155] appear in an interdisciplinary form-problem that can be solved using simplexity.
In fact, when Berthoz writes that the corner of a street is a place where simplexity should dominate, that the roof is "a simplex gesture" or that stairs represent a symbol, a relationship, a transition between the inner world and the outer world [Berthoz 2011, pp. 153, 154], he talks about the simplexity of space (corner, roof) and its social and psychic perception (stairs). But this is not all he talks about.
He also explains how space becomes simplex (e.g., a space-corner). He writes that the corner [of a street] can be cut, thus allowing vision, that always anticipates a change in direction, to guide the way, so that we do not come face to face too abruptly with someone else [Berthoz 2011, p. 155].
(By trying to summarise I come closer to simplex representation).
When a person turns a corner he determines a complexity of space that can be simplified by cutting the corner. This simple "cut" makes space simplex.
So, if a physical "cut" simplifies the complexity of real space, how is it possible to simplify the complexity of representation, and make it simplex?
Clearly Berthoz does not offer direct answers but references to that "combination of simple rules" on which simplexity is based.
References he promptly provides. In fact he writes that in a complex world simplification is never simple and requires instead that we choose, refuse, connect and imagine [Berthoz 2011, p. XI].
While bearing in mind that every map represents the drawing of a complex (urban) world (space) that must be simplified, the above are the keywords needed to create urban maps in which material and immaterial phenomena, problems and solutions coexist.
According to Berthoz, drawing is in itself "a simplex mental tool" [Berthoz 2011, p. 143], and in this case its simplexity is required to involve the individual who links his action to the represented space.
The next paragraph will present two examples of simplex representations.

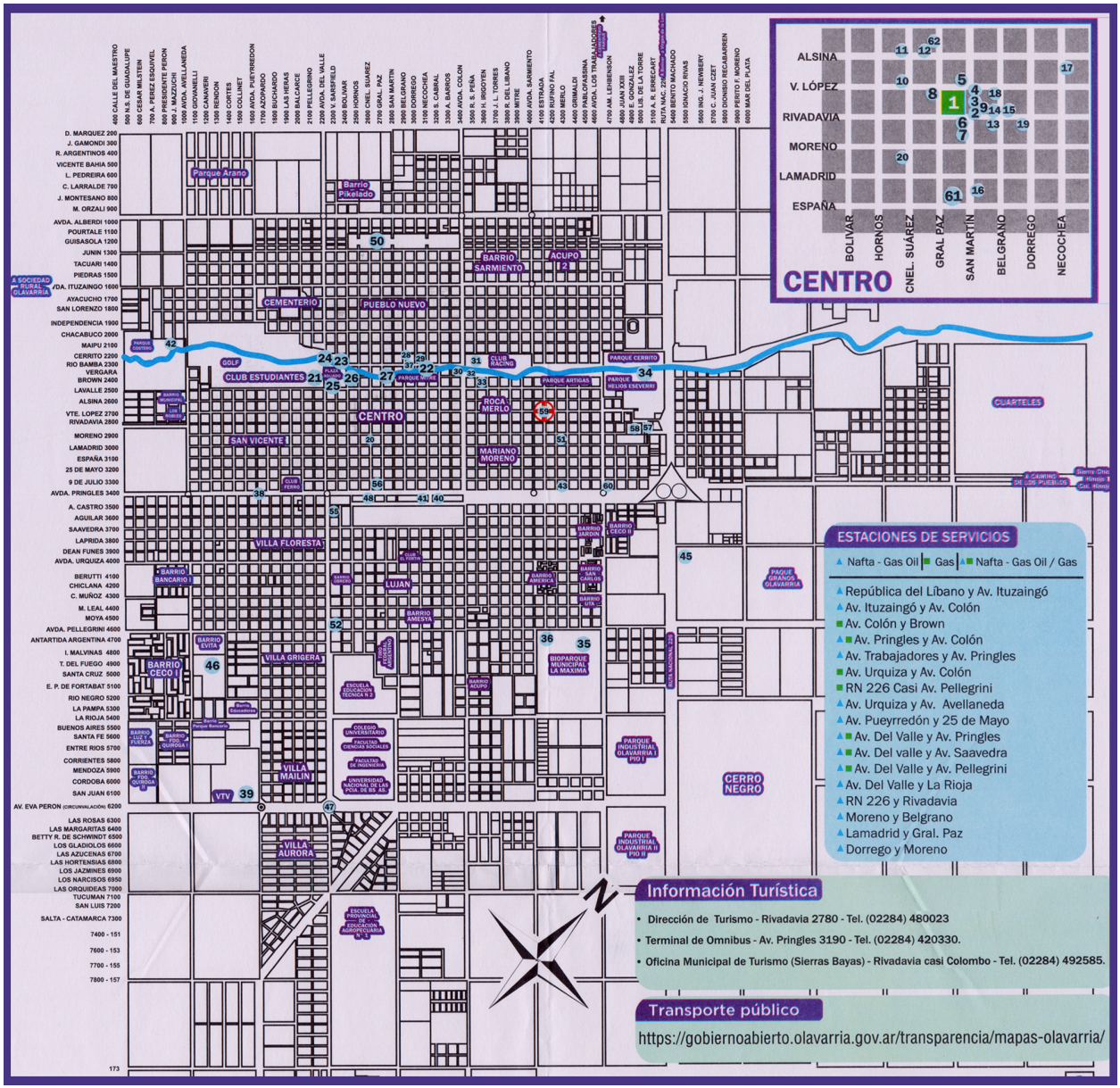

Fig. 9. Olavarría, Tourist Map, 2019. Olavarría, Province of Buenos Aires, Argentina. Map, property of the author.

"Simplex" representations

One example of simplex representation is the map of the New York subway drawn by the designer Michael Hertz in 1979 [6] and still used as a basis for the current map (fig. 3).
Hertz superimposes the numerous subway lines on the form of the city, but he also reveals its fabric. By introducing several physical-spatial elements in New York into the map (urban drawing and transportation) he represents a greater level of complexity.
However, Hertz's graphic strategy (reinterpreted using Berthoz's words: choose, connect, imagine) allows an individual to interpret and use the complex transportation system as well as identify his position underground compared to the space above ground. Hertz transforms the underground network into a surface network, turning what is actually more complex into something simpler and more decipherable. This involves psychologically simplifying representation by removing the uncertainties and fears associated with being underground. This idea is confirmed by the psychologist Arline Bronzaft who worked with Hertz on the map: "It was the 1970s [...]. people were fearful of going on the subways. [...] We wanted people to use the map to see the sights of New York" [Bronzaft, 2004].
A graphic and methodological revolution broadening the map's objectives and encouraging individuals to relate to their actions in space (movement in the subway).
The map was innovative even compared to the previous map drawn by the designer Massimo Vignelli in 1972 and now in the MoMA in New York [7]; in Vignelli's map the subway lines are represented over a simplified and chromatically abstract urban form.
In most cases, the standard, up-to-date maps of the subway system isolate the lines from the city's fabric (also to avoid graphic overload); as a result the urban form and the size of the city can be interpreted and perceived thanks to the greater or lesser number of lines. For example in the map of the Tokyo subway (fig. 3). It is another simplex representation where the dense network of underground routes, drawn against a completely white background, renders the complex urban density above ground and also illustrates another space (underground); the complexity of this latter space is created by the links between places, identified by their name and reciprocal proximity.
The map not only provides the extensive information required for people to use it, it makes that information visible by using abstract graphics which, semiologically speaking, are entrusted to plastic elements: i.e., colours, lines and space; the map also succeeds in deciphering the complexity above ground (as urban density) and representing the complexity under the ground (as connection). The fact there is no urban drawing appears to be a graphic strategy to encourage individuals to think of the underground as a structured and defined layer of the city. Another city with which to relate: the underground city.
In actual fact, apart from the objective graphic and functional features required to interpret subway network maps, the absence or presence of the urban drawing in these maps can become a conceptual choice regarding the city's structure; it can be designed and represented either in levels (e.g., the map of Tokyo) or as an ensemble, like a level that shows everything (e.g., the map of New York) (fig. 3).
Obviously in some maps, e.g., tourist maps, the urban drawing is crucial and necessary. The *Map Walking Tours* of Sydney (fig. 7) is one such map where three routes are illustrated and represented in the urban drawing.

Space-representation-the individual-action

It doesn't matter what kind of map is used (as illustrated by Hertz's work), an urban drawing allows individuals to decipher the geometries of space and associate them with the action they are performing, whatever that action may be (in Hertz, movement underground, in the map of Sydney, movement above ground). According to the mathematician Henri Poincaré "to localise an object in such a point of space simply means that we represent to ourselves the movements that must take place to reach that object" [Berthoz 2011, p. 131].
All this means greater interaction between the individual and the representation because it becomes an integral part of the individual's action.

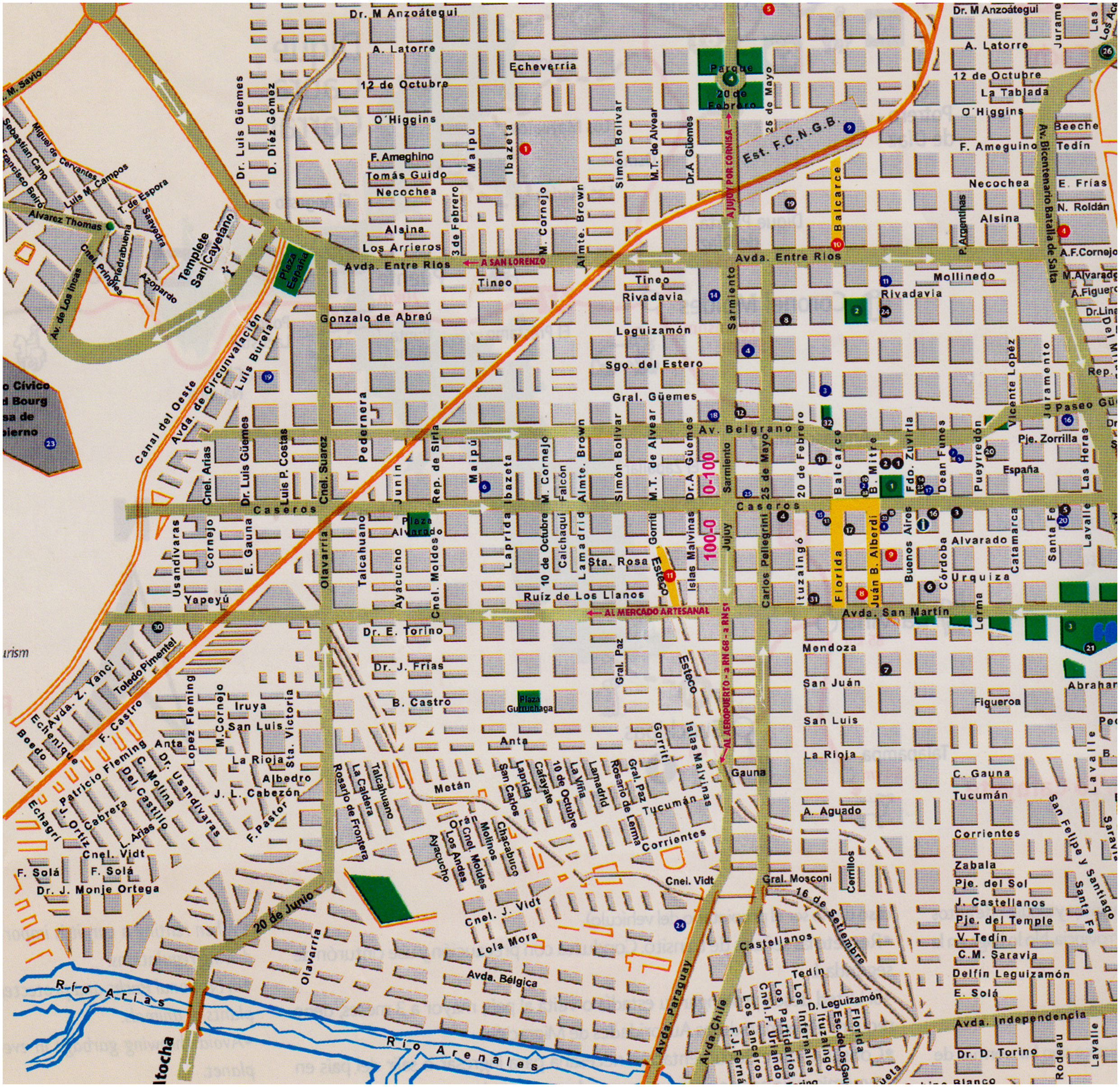

Fig. 10. Salta, Tourist Map, 2018. Salta, Province of Salta, Argentina. Map, property of the author.

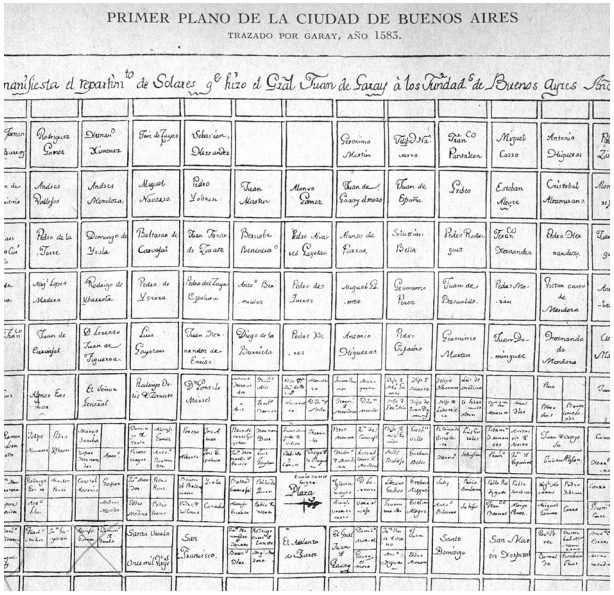

Fig. 11. Second foundation of Buenos Aires. Division and distribution of the lots by J.de Garay to the founders of Buenos Aires, 1583. Taullard 1940, s/p.

As mentioned in the introduction, man's ability to act in space is behind the individual-space-action relationship; it involves the vital impulses of the organism, propriocetion and kinesthesia as well as the wonderful, plastic ability to move in the environment [Morabito 2020, p. 16].
As concerns maps, these vital impulses are "managed" by the brain that performs a (spontaneous) pre-vision of the movement in space through its representation, allowing and triggering the kinaesthetic process.
(Please refer to my considerations at the beginning of this article regarding foresight as one of the brain's main functions).
The brain interacts directly with the map as if it were a real space; it uses space actively and not passively, because space, in real life – as per Merleau-Ponty's phenomenological tradition – is a dimension actively elaborated rather than passively received [Merleau-Ponty 2003].

Although linking the action to space through representation seems obvious, for psychological reasons (e.g., Hertz's map) or functional reasons (e.g., the map of Sydney, where space is the object of the action), deciphering the geometries of space can be linked, as stated by the philosopher and psychoanalyst Miguel Benasayag, to "processes of what we call 'geometric thought' [that] correspond to existing forms, bearing in mind that, in line with the definition by the French epistemologist Jean Petitot (1980), 'form is the phenomenon of the organisation of matter in general'. This means that [...] we process the reality of the forms [...] in the sense of what is manifest as forms in relation to other forms" [Benasayag, 2016, p. 132].
Then again, the urban, as a form of organised matter, is a complex of forms in relation to other forms; the reality of these forms is absorbed (processed) using the 'geometric' or 'topological' thought "that western tradition calls 'instinct'" [Benasayag, 2016, p. 131].

Conclusions

Conceptually speaking the representation of space in urban maps emerges as a solution to the spatial, social, psychological and anthropological phenomena and problems that coalesce and interact in the complex relationship (physically concentrated in the urban system) between space, representation, the individual and action. Within the framework of these representations, this can prompt further studies and interdisciplinary researches.
From a formal and functional point of view, the complexity of the urban system and city system – as an ensemble of interacting physical-spatial and social elements – is represented in the maps using simplified representation, i.e., using a figurative crasis between complexity and simplicity leading to simplex representations that interact directly with the brain and are capable of communicating all the data regarding the aforementioned physical-spatial elements in the maps (urban drawing, transportation, trade-tourism).

Notes

The original text of this essay is in Italian. English translation by the author. All the quotes from Italian books, books translated into Italian, or other Italian language sources, have been translated by the author from Italian into English.

[1] Item: Complexity. In Treccani. Online vocabulary, <https://www.treccani.it/vocabolario/complessita/> (accessed 2020, December 10).

[2] Certainly not exhaustive, neither for space nor for maps.

[3] These are details of the maps, useful for the analysis.

[4] The maps of Sydney and Salta only show part of these cities, while those of Tokyo-Akihabara and Olavarría show the whole city.

[5] Charles Booth, Maps of London Poverty. East & West 1889. London.

[6] With his studio Michael Hertz Associates.

[7] M. Vignelli, J. Charysyn, B. Noorda, Unimark I.C., NY, *New York Subway Map*, 1970-1972. See: https://www.moma.org/collection/works/89300 (accessed 2020, December 10).

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