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THE COGNITIVE DYNAMICS OF CONFIGURATIONAL UNDERSTANDING

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Abstract

This paper investigates how people retrieve hierarchical information from spatial information depicted in maps. The aim of the paper was to understand the role of metric and configurational aspects of space in shaping people`s understanding of spatial networks.

The experiment consisted of identifying the main streets and junctions in an artificial map, lacking any type of information regarding land uses or street names, where all the streets had the same width.

A total of thirty-six people took part in the experiment. Their responses were analyzed using two methods: by counting the number of axial lines, segment lines or continuity lines involved (Figueiredo and Amorim 2005; Figueiredo and Amorim 2007), called Line Analysis, or by counting the number of choice nodes they involved, called Node Analysis.

The main findings show that when configurational and metric properties of salient streets were synchronized, people retrieved hierarchies in a predictable manner, whereas when such dimensions were not synchronized, hierarchies were perceived in a more disorganized way.

1. INTRODUCTION

During the last thirty years of research and real-world studies accomplished all over the globe, the space syntax has consistently shown that movement patterns in cities and buildings tend to be strongly related to the configurational properties of spatial layouts (Peponis, Hadjinikolau E. et al. 1989; Hillier et al 1993, Turner 2003). It has also been shown that individuals' trajectories in virtual worlds are affected by the syntactic properties of these environments (Conroy-Dalton 2001; Conroy-Dalton 2003). As a result, space syntax theory has made it possible to predict changes in movement patterns derived from changes in the environment's configuration.

However, none of these studies have thus far attempted to elicit the reason behind these regularities at a more fundamental, cognitive level. This is due to the fact that until now, most investigations have failed to overcome what Montello (2007) called the *causal* problemof Space Syntax. According to him, it could be misleading to claim that people can read and use configurational information of space based on the fact that highly integrated spaces attract more people than less integrated ones (a finding reported by various syntactic studies, see for example, Hillier et al 1993 or Hillier & Iida 2005), since this association could be the result of a learned behavior. Thus, *"more integrated locations are likely to be more familiar to the average person, to be experienced earlier on exposure to a new place, and to be experienced more."*(Montello 2007iv:06).

Here it is argued that the causal problem posed by Montello means that we have not yet whether (and how) the idea of spatial configuration is retrieved by people. This is the topic of this paper. What kind of information do people extract from spatial configurations? How is this information used when qualitatively assessing a spatial network?

The paper will concentrate on map usage. By asking people to outline the main street, the three main streets, and the three most important junctions in a map, this research will overcome Montello´s causal claim permitting us, at the same time, to find out whether people retrieve configurational information.

2. METHOD

Scenario

In order to avoid any criticism regarding previous experiences with a spatial network that might favour people choosing a specific street, this experiment created an artificial map in which all environmental information such as street names, land uses or landmarks were concealed. This network was also highly irregular and might be part of the urban fabric of any European city.

By aiming to force individuals to assess only configurational and metric information about streets (that is, how connected and how long each street is), in order to retrieve their importance, all streets had the same width. As a result, the map resembled a Nolli map[1] (see figure 1), with the sole difference that no private spaces were shown.

1This technique, developed by GiabattistaNolli (1701-1756) for the map of Rome, is popular in urban studies.

Participants and procedure

A total of 36 subjects (18 women, 18 men) participated voluntarily in the experiment. Most individuals were students at University College London or University of London. They were approached in the vicinity of UCL`s main campus and asked to participate in an experiment about map reading. All respondents were native English speakers.

As means to avoid any bias in the responses, participants from the Departments of Geography or Architecture were excluded. Most subjects were in their twenties (M=24.97, SD= 7.86).

Participants were given a set of three charts, all of which contained the same map but demanded a different task. All charts were presented in the same order[2].

The first chart asked subjects to read carefully the map and to read the following instruction: "*Please look carefully at the map and outline what you think are the MAIN streets (3) of the system."* Once subjects completed the task, they were asked to encircle the three MOST IMPORTANT junctions of the map (chart 2), and its MAIN street (chart 3). They were not allowed to see their previous answers.

For the sake of simplicity, these questions will be designated as follows:

- Question A: please outline the three main streets
- Question B: please highlight the three most important junctions
- Question C: please outline the main street of the system

[2]A second experiment is plannedto present charts in a random order

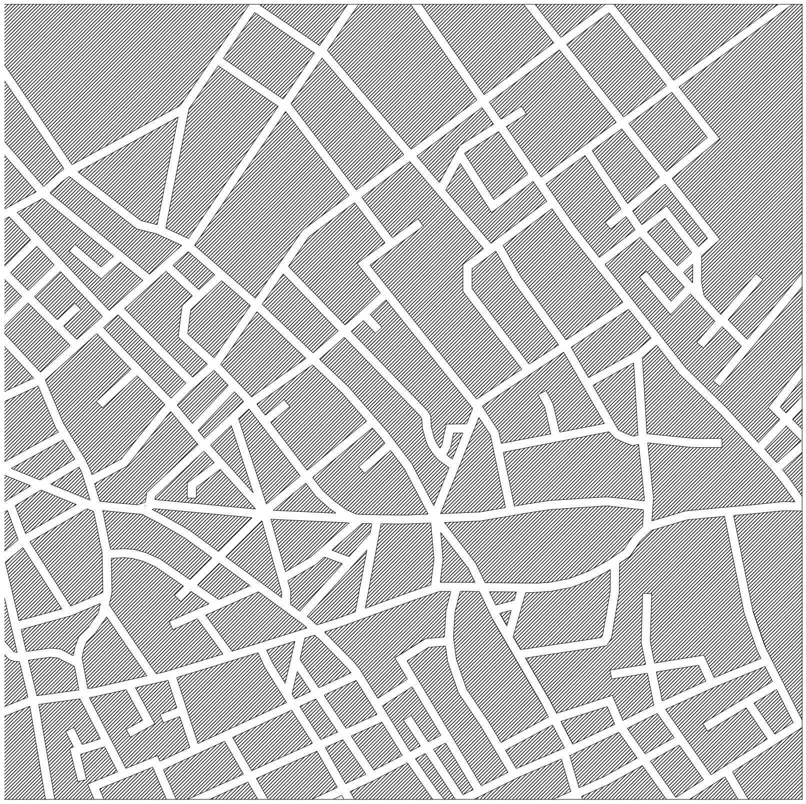

Figure 1: the map tested in this experiment

Most people could easily complete the task in few minutes. A small pool of subjects asked for a clarification of the term “main street’. In these cases, the person in charge of the experiment responded by suggesting the subjects outline what they considered to be the most important road of the map.

Methodological preliminaries

If participants` paths and marks are to be analysed and compared against spatial data, the first question is to decide how. This in turn demands the definition of two aspects: which spatial model will be employed to analyse the map, and how participants` answers will be unpacked in order to compare them against spatial data.

Selecting spatial models

The most obvious way to analyse spatial data is to use the best-known syntactic representation: the axial map. This is due to the fact that most cognitive studies undertaken by researchers belonging to the space syntax community have, so far, employed axial maps. As a result, the findings encountered in this experiment will be potentially comparable with those from other studies. However, axial analysis sometimes falls short in capturing a network’s underlying spatial structure, especially when the network is of an irregular character, like the one employed here. In fact, it has been declared that axial analysis imposes an exaggerated cost for the slight deviations of streets (Stonor 1991; Dalton 2001; Ratti 2004), which result in what has been named the “Manhattan problem” (Stonor 1991) of axial representations.[3]

In the last ten years, a new series of computational packages have tried to overcome the Manhattan problem. One of the earliest of such attempts is Dalton`s “fractional analysis” (Dalton 2001), a procedure that topologically assesses a network according to the angle of incidence of its lines. A similar procedure has been recently proposed by Turner (Turner 2005) under the name “Segment analysis” which, rather than assessing the topological “cost” between two axial lines according to their angle of incidence, it decomposes each axial line into multiple segments. These segments are then analyzed in terms of their topological depth with respect to all other segments. Hillier and Iida (2005) have recently shown that segment angular analysis can robustly predict people’s movement patterns in a large area of London. Turner (2005), on the other hand, found that segment analysis could better capture movement patterns than axial analysis.

The last method to be used here is Figueiredo`s contuinuity lines, or the Mindwalk[4] analysis (2005; Figueiredo and Amorim 2007). Unlike segment analysis, this perspective does not dismiss axial lines as a means to represent space but “merges” them according to certain angles of aggregation.

Analyzing people’s choices

Once we have data about people’s choices, how do we analyse it? It is fairly obvious that this depends on the type of question asked of the subjects. For example, questions C and A asked persons to outline, respectively, the main street of the map, and the three main streets of the map. These questions, therefore, resulted in a series of different paths. Question B, on the other hand, told persons to mark the three main junctions, which means that answers resulted in a series of points. Now the original question could be reformulated as: how could these paths and points be compared against the configurational or metric properties of the map?

A possible solution is that of Peponis et al (1990), which consisted in decomposing a spatial layout into a series of *choice nodes*, or spaces that demanded that individuals amend or continue their trajectories. According to Peponis, choice nodes were spaces where two or more axial lines intersected. It follows then that for any choice node, a set of mean configurational values (e.g, Global Integration, Local Integration, Choice, Connectivity) can be calculated. This was done by summing up all axial lines that were encountered at each node and then dividing this value by the number of lines.

The second mechanism employed to analyse people`s answers consisted in observing which axial, segment of continuity lines were used by subjects when responding to questions A or C.

The resulting series of techniques employed in this experiment can be summarized as follows: spatial networks were analysed by using Axial analysis, Segment analysis and Mindwalk analysis, whereas people`s answers were studied by examining how many choices nodes or lines they had named (see Table 1).

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[3] The Manhattan problem alludes to the fact that Broadway, New York`s most important commercial axis, is not the most integrated street but merely a relatively well-connected one in axial analysis

[4]The continuity lines analysis (or Mindwalk) model is a close relative ofthe axial analysis. Recently created by Lucas Figueiredo as part of his MSc thesis, the model employs two of the fundamental assumptions of syntactic analysis: that urban space can be represented as a set of axial lines, and that these lines can be examined in terms of their configurational properties.

Table 1: type of analyses carried out in this chapter

		SPATIAL MODELS			
		Axial Analysis	Segment Analysis	Continuity Lines Analysis	
				15º [5]	30º
SPATIAL ANALYSIS	Nodes	Axial Node Analysis	Segment Node Analysis	Mindwalk Node Analysis (15º)	Mindwalk Node Analysis (30º)
	Lines	Axial Line Analysis	Segment Line Analysis		

3. RESULTS

Descriptive analysis of data

Figure 2 shows participants' answers regarding the three main streets of the map. As can be seen, paths made by respondents were concentrated in five avenues: three of them move obliquely, whereas the remaining ones move in a horizontal manner, thus dividing the map into an upper and a lower part[6]. All paths were slightly sinuous, reflecting the fact that the grid itself was irregular.

Figure 3 shows participants' answers regarding the three most important junctions. Here it is possible to see that a triad of junctions running horizontally concentrated the vast majority of marks, whereas a pool of secondary junctions (three of them placed along an extended diagonal path), concentrated far fewer choices.

Finally, figure 4 illustrates participants' choices concerning the main street. The pattern strongly resembled the one observed in figure 2,but was limited to only three avenues, two of which move in a rather horizontal manner, and the last one moving diagonally.

[5]A detailed explanation of the reasons behind the selections of these angles will be given in the second part of this chapter (chapter 5b)

[6]A couple of additional paths were also marked by two persons

Figure 2: Subjects' answers regarding the three main streets

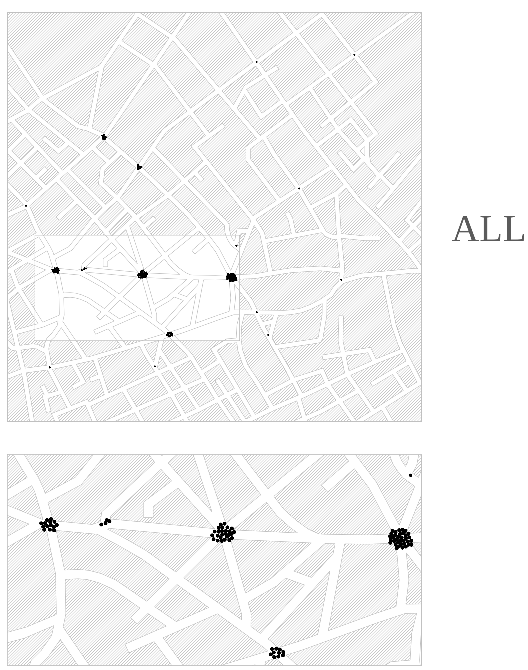


Figure 3: Subjects' answers regarding the three most important junctions

Figure 4: Subjects' answers regarding the main Street

3.1.-Configurational analysis

The first part of the analysis examined whether the number of lines or choice nodes varied according to the gender of the respondent. A series of Mann-Whitney tests detected no differences for any of the models employed. This means that males and females did not differ in the number of axial lines or choice nodes they selected for either questions A or C[7]. It was then investigated whether there was any relation between the number of lines or choices nodes selected by a person when responding to question A or C. No statistical differences were found for either subject[8]. Finally, it was investigated which configurational or metric measure could best predict people`s answers.

Figure 5 shows a manual axial map of the scenario tested in this experiment, which was built according to the principle of making the fewest possible straight lines that fill the open space of the network. The number of axial lines was 159. Figure 6a shows the ID number of each line, as delivered by Depthmap[9].Figure 6b

[7]In the Axial Lines analysis, the test's results were (U: 138,0; p>0,05) when one main street had to be selected and (U: 128,5; p>0.5), when three main streets were marked. In Axial Node Analysis, these results were (U: 141,5; p>0,05 and U: 142,0;p>0,05) respectively, whereas in Segment Line Analysis, the results reached the values of (U: 141,5; p>0,05) when one street was chosen, and (U: 142,0;p>0,05), when three streets were chosen. Finally, in Mindwalk Line Analysis, results were (U: 148,5; p>0,05 y U: 117,5; p>0,05)for questions A and C respectively. The results regarding Line Node analysis were identical to the Axial Node Analysis, since the number of nodes did not vary in Segment or Mindwalk Node analyses.

[8] In Axial Line Analysis, the association was (rs: -.24; p>0.05), whereas in Axial Node analysis, this value was (rs: -.127; p>0.05). In Segment Line and Mindwalk Line Analysis (15º), the association reached the values of (rs: -.19; p>0.05, (rs: -.195; p>0.05) respectively.

[9]This number was delivered automatically by Depthmap, so the task consisted in translating this information into a more workable format.

shows the series of choices nodes existing in this network[10]. The number of choice nodes was 186.

Following Conroy-Dalton`s procedure for examining participants' traces (Conroy-Dalton 2001), in this experiment, the data was analyzed as follows: first, each person's answer was analyzed as a protocol of choice nodes or lines. For example, if person X passed through nodes 1, 2 3 and 4, his trajectory was defined as the sequence of nodes 1-2-3-4. Likewise, if the same person traversed axial lines 5-6 and 7, his path was described as the chain 5-6-7.

An example of this procedure will be presented by analyzing a path made by one of the participants that took part in this experiment. The leftmost image of Figure 7 shows person 5`s answer when selecting the main street of the system. Analyzed from the point of view of line analysis, this path involved the axial lines 73-77-78-70-83-109-125, as shown in figure 7. However, from the point of view of the choice nodes that this path involved, this path can be summarized as the sequence 6-1-12-186-23-31-32-33-49-82-85-86-87-88-89-90, as figure 7 illustrates.

Since subjects had to respond to three questions, all answers made by participants involved the selection of a different set of nodes and axial lines. For example, subject X chose axial lines 1,2 3,4 and nodes 9, 8 and 7 when selecting the main street of the map, whilst subject Y selected axial lines 3, 4 and 5 and nodes 9, 11 and 12 when responding to the same question. It follows that taken altogether, axial lines 3 and 4, as well as node 11, were chosen twice, while all other remaining axial lines and nodes were selected just once. The sum of all participants` choices resulted in what was called the Node Total Occupancy Index (NTOI), and a Line Total Occupancy Index (LTOI), two measured that reflected how often a line, or a choice node, were chosen by subjects.These measures were then compared to each line or node's configurational and metric values[11].

In a similar manner to the Axial Line Analysis, the first step of Segment Analysis consisted of placing an ID number for all segment lines in the map. This was realized by translating the information delivered by Depthmap into a CAD, and then using this program to study people's paths. The total amount of segments in this map was 369[12].Once all segments were identified, each person's answer was examined according to the number of segments and choices nodes it comprised.

Unlike Axial and Segment analyses, Mindwalk analysis depends on the user's ability to define the angle of aggregation of lines. In order to make this decision, this experiment studied the map itself, in order to see whether there was any pattern on it that could serve to set the angle of aggregation.

In order to carry out the first part of the analysis, a 5º aggregation angle was employed to merge the axial lines. It was observed that the number of lines existing in the map decreased significantly as a product of line aggregation, going from a total of 159 when no angle was applied, to about 120 when a 40º angle was utilized. Nevertheless, this decline was not steady. For example, in the 25º-30º interval, only one line was merged, whereas in the 30º- 35º interval, 5 lines were aggregated. With these results at hand, the next step observed whether there was any distinguishable pattern in the number of lines aggregated in each interval.

[10] For the purposes of this study, choices nodes were considered as nodes that required subjects to define alternative paths in order to pursue their trajectories. This means that intersections leading to cul de sacs were not considered to be choice nodes.

[11] A Spearman technique was chosen due to the asymmetric distribution of some variables. While choice, Line length and Connectivity are abnormally distributed, both Global and Local Integration are normally distributed.

[12] This number corresponds to all lines larger than 0.1, the shortest line in the map. Since Segment Analysis tends to generate a large pool of metrically meaningless lines (resulting from the encounter of three or more axial lines that do not intersect each other at an exact point), this analysis discarded about 15% of lines.

This basically detected three situations: one that went from 0º to 15º, in which a large number of lines were merged, one in which this process came to a halt (15º to 30º), and a final phase (30º to 40º) in which the velocity of line merging reassumed its pace. Based on this evidence, it seemed reasonable to run the Continuity Lines using the threshold angles of 15º and 30º.

Figure 5: axial breakup of the map used in this experiment

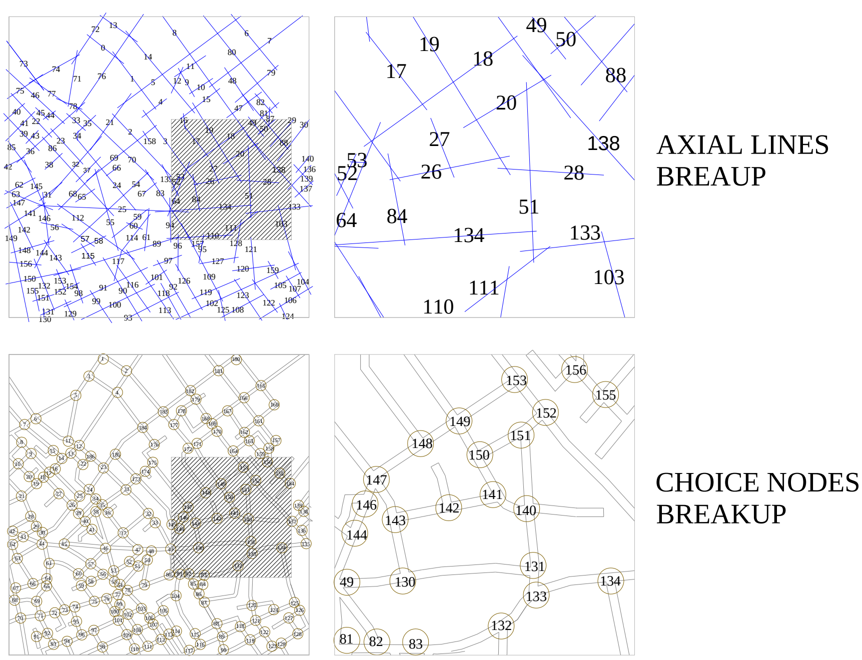


Figure 6a and.6b (top left): axial breakup of the map

Figure 6c and 6d (bottom left): choice node breakup of the map

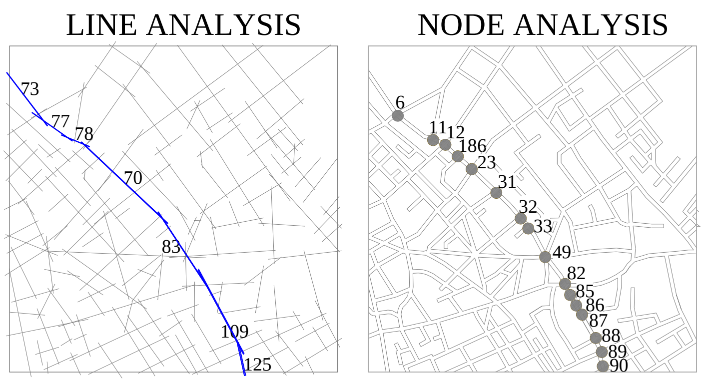
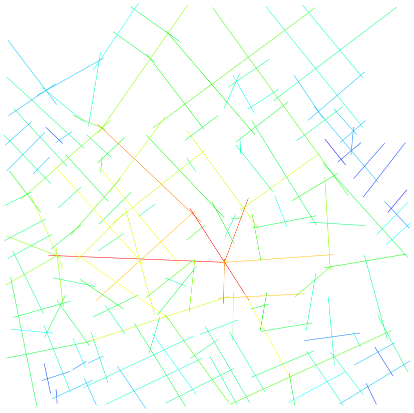
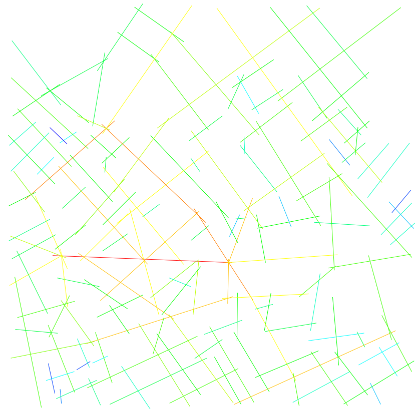


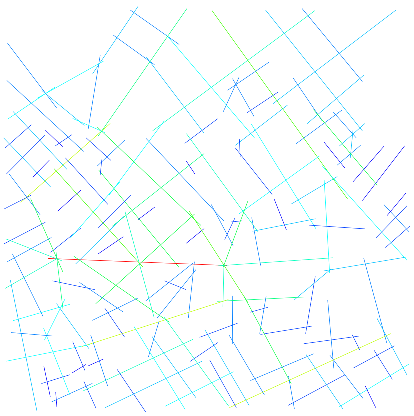
Figure 7: subject 5`s path when responding to question C
Figures 8a (left): axial lines involved in person 5`s answer to question C
Figure 8b (right): choice nodes involved in person 5`s answer to question C



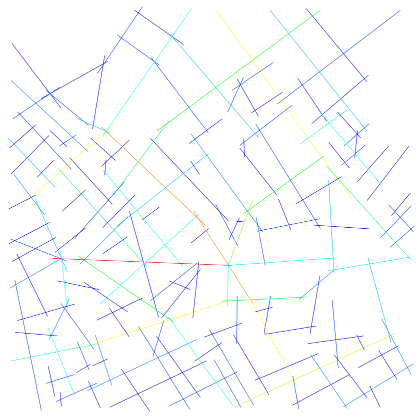
Global Integration



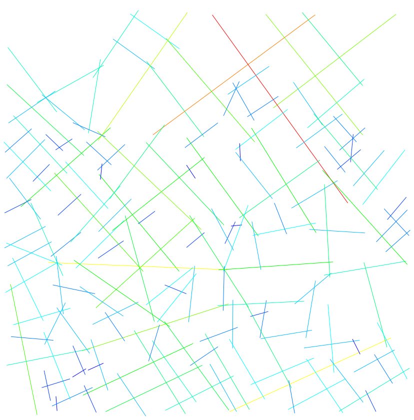
Local Integration



Connectivity



Choice



Line Length

Figure 5.9a to 5.9e: Axial Analysis

3.2 Summary of results

Table 2 shows the configurational or metric measure that most efficiently captured participants' answers to questions A, B and C. In order to shorten the understanding of data, only results concerning Node Analysis (the most efficient methodology to predict people's choices) will be displayed in this paper.

Here it can be noted that in both Axial and Segment analyses, configurational variables were more efficient than metric ones in predicting how people retrieved hierarchical information. Results also suggest that the predictive power of these models improves in parallel with angular sensitivity, meaning that Axial analysis reflected, to a lesser degree, participants' choices than Segment analysis, and that the latter was less efficient than the Continuity Lines analysis. This seems concordant with results obtained in real-world scenarios (Turner 2005; Hillier & Iida 2005) which have found that those techniques that are more sensitive to the angular deviation of lines better capture people's movement patterns. However, when lines were merged (as occurred with Continuity Lines Analysis), the metric properties of networks also started to explain people's qualitative judgments of networks.

Despite these suggestive results, a cautionary note is necessary. In all but segment analyses, configurational and metric measures were highly associated, meaning that highly connected lines were likely to also be highly integrated or extended ones. Moreover, this pattern was more evident in the Mindwalk analysis than in the Axial or Segment analyses[13], which suggests that the synchronization between metric and configurational factors increased as a result of line aggregation.

The problem with this trend is that in most cases, the predictive power of metric factors was very similar to the predictive power of any of the configurational measures examined here. This means that it is not possible to contend, unambiguously, that persons gave more importance to configurational aspects rather than to the metric aspects of lines. On the contrary, it is likely that, in order to retrieve hierarchical information of paths, the main strategy employed by individuals was to pay attention to the metric aspects of streets (which are observable and measurable to the naked eye), rather than to assess their configurational information.

There is an obvious manner to solve this dilemma. If the longest line was also the most *popular* street of the system (the line chosen by the vast majority of individuals as a main street), and if the second longest line corresponded the second most popular line of the map and so forth, there is no way to claim that other factors apart from metric ones influenced people's judgments. On the contrary, if a line`s length was not directly associated with this line`s popularity, it could be argued that metric factors could not fully explain how people retrieve hierarchies in maps.

Table 3 investigated this idea[14]. Using a method that ranked the lines on the map according to their configurational or metric salience, this table shows the map`s degree of synchronization between metric and configurational measures. The first part of the table has two sections, namely columns (i) and (ii), which correspond to questions C and A respectively. Each of these sections is, in turn, composed of three small columns. One shows each line`s ID number, as delivered by Depthmap or Mindwalk. At the right of this column, another column shows the number of individuals for whom these lines were seen as a main street. Finally, the third column shows the percentage that these individuals represent of the sample. The

[13]The meanassociation between the metric measure of Line Length and the configurational measures of Connectivity, Global Integration, Local Integration and Choice was r= 0.698 (SD 0.137)

[14]For the sake of brevity, this exercise will be restricted to Mindwalk 30º line analysis

remaining five columns at the right of the table show the configurational and metric measures tested in this experiment.

As the table shows, line Nº 58 was the longest, the most connected, the most globally and locally integrated and the line most frequently chosen on the map. Was line Nº 58 also the most frequently used line of the map?

The answer is yes. Here one can note that 52.7% of participants marked line Nº 58 as the main street, whereas 88.8% of participants selected this line as one of three main streets.

But what about the second longest path of the map, line Nº 4? Was this path the second most popular street of the sample as well?

Unlike path Nº 58, path Nº 4 was neither the second most popular street when three streets had to be marked, nor the second most popular street when just one street had to be selected. The same can be said of the third longest path (line Nº 22), which was the third most popular street when three streets were marked, but the second most popular street when just one street had to be chosen. How can this puzzling phenomenon be explained?

A possible answer could be that lines Nº 4 and Nº 22possessed a lower degree of synchronization between metric and configurational values than line Nº 58.For example, line Nº 4 was the second most globally integrated line, as well as the line of second largest choice value of the sample. Nonetheless, it was not the second most connected line, nor the second most locally integrated line. The same can be said about line Nº22, which, despite being the third longest line, did not form part of the triad of lines with the largest Global Integration or Choice values.

Table 3 suggests that the synchronization of metric and configurational factors in the lines was crucial in determining people`s choices of main streets. For example, 52.7% of people selected line Nº58, or the line in which all configurational and metric measures were synchronized, as the main street of the system. By comparison, only one person chose line Nº4, which, despite being the second longest line of the map, did not have the same degree of synchrony between its configurational and metric factors. Similar results were found when three streets, rather than when just a single street, had to be chosen.

In short, it seems that Line Length itself could not fully explain how respondents perceived hierarchies in maps, for they selected as hierarchical streets only the lines whose metric and configurational aspects were synchronized.

Figure 8 indicates the location of lines Nº22, Nº69, Nº 58 and Nº4 in the map. Now it is possible to see that line Nº 4 did not connect the map score with its outskirts, in the same way that lines Nº22 and Nº 69 did.

Table 2: Node Choice Analysis. Association between people´s choices and different configurational methods

	Type of Analysis			
Question	Axial	Segment	Mindwalk (15º)	Mindwalk (30º)
Three main streets (question A)	**0.636** (Choice)	**-0.658** (Mean Depth)	**0.719** (Choice)	**0.771** (Line Length)
One main street (question C)	**0.488** (Global Integration)	**-0.642** (Mean Depth)	**0.644** (Global Integration)	**0.682** (Global Integration)
Three most important junctions (question B)	**0.246** (Choice)	**-0.282** (Mean Depth)	**0.297** (Local Integration)	**0.282** (Local Integration)

Table 3: An examination of metric and configurational factors of highly-chosen paths

	People's choices about one main street			People's choices about three main streets			Choice (ID)	Conn (ID)	Global Int (ID)	Local Int (ID)	Line Length (ID)
	ID	N	%	ID	N	%					
First	58	19	52.7	58	32	88.8	58	58	58	58	58
Second	22	10	27.7	69	27	75	4	22, 69	4	22	4
Third	69	6	16.6	22	23	63.8	69	4/7/ 88	53 / 69	69	22
other	4	1	*3*								
		35	*100*								

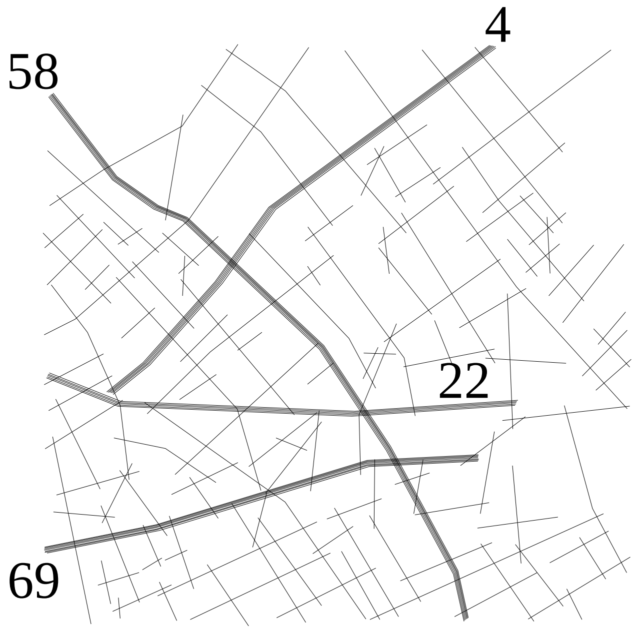


Figure 8: paths Nº 58, 4, 69 and 22

4. DISCUSSION

One way to read these results is to say that the reason why Mindwalk analysis was more efficient in predicting people's judgments than Axial and Segment Analyses was that this model captured what Morrison (1981) called the principle of *arteriality*. This contends that an underlying structure exists in some natural phenomena, such as hydrological systems, in which hierarchical paths tend to be sinuous, whereas less hierarchical ones are more broken.

Marshall (2004) recently suggested that the principle of arteriality is an underlying structural property of networks, one that is normally "taken for granted" (Marshall 2004) but rarely studied in depth by planning agencies. According to Marshall, arterial streets have the virtue of coordinating metric and topological aspects of grids, making it possible for people to infer the relative importance of streets in a network. *"We usually know a main road is so called because is a "big road," a "busy street" or a "strategic road." The correlation between road standard flow and strategic status seems to be intuitively simple. Even if national road networks tend to be organized by designation, it appears to be a simple reflection of form or use. However, things are not necessarily as straightforward as this. If we look more closely, we find that designation is, generally speaking, not by form or use but by relation. And this is not a trivial academic distinctions: it provides a key to understanding hierarchy and the structure of the urban layout"*(Marshall 2004:58).

Based on the results of this experiment, it will be argued here that Marshall's ideas could be refined by saying that people infer the relative importance of streets based on the synchrony between the metric and configurational aspects of these streets. This does not mean that subjects do not retrieve hierarchical information about space when no coordination between metric and configurational variables of space exists, but that the construction of shared knowledge (Surowiecki 2004), or knowledge that seems to be implicitly agreed upon by most individuals would be more difficult to achieve. Furthermore, it will be argued that when no coordination exists between the configurational and metric factors of salient lines, the retrieval of hierarchies will be more subjective and unpredictable.

It is inevitable to separate these findings from space syntax theories. In fact, Hillier (1999) has mentioned that urban space is characterized by a synchrony between metric and configurational variables, which means that longer lines would tend to be integrated ones. According to Hillier, the metric factor of line length is a decisive aspect in determining how easy or difficult it is for a person to retrieve a description of the system. He also added, *“the degree to which we can arrive at an abstract conception of the system as a whole from a series of perceptions of its parts depends on its metric organization, or perhaps more accurately, on the topological organization of metric properties"*(Hillier 2003:18).It seems that for this process to occur, metric and topological aspects of lines should be organized in such a way that longer lines should also be salient lines in configurational terms.

From a cognitive point of view, the hypothesis proposed here is supported by recent investigations in neuroscience (Kelso 1995, Ibañez, 2008; Thomson 2007). Kelso has suggested that people`s cognitive apparatus is intrinsically instable and dynamic, meaning that a given behavioral pattern (as per the identification of a main street in a map) depends on the coordination of two or more parameters. As a consequence, people will make sense of their environments when these parameters are in a state of relative equilibrium. However, a change in these parameters will result in the emergence of anew behavioral pattern. It follows than that people`s cognitive processes are neither stable nor can be understood based solely on the examination of a single variable, but a dynamic process defined by multiple factors in which temporal *cognitive plateaus* can be found.*“There is a fundamental need to understand the most complex systems of all, ourselves. Even the most ardent reductionists now admit that the brain cannot be understood solely on the basis of the chemistry and biophysics of single cells, But there is a huge void in out knowledge of what single cells do versus many of them do when they cooperate. That’s why is crucial to discover the laws and principles of coordination of living things. It is coordination that lies at the root of understanding ourselves and the world we live in”* (Kelso 1995:288).

When understanding the question this way, this experiment`s results could be a interpreted as an indication that the retrieval of spatial hierarchies in humans is an intrinsic cognitive ability that depends on the synchronization, rather than the competition, of metric and configurational aspects of space. But, how does this mechanism work?

In order to respond to this question, a heuristics will be proposed here (see figure 9). This proposes that the retrieval of hierarchies in maps is a process affected by three aspects: the perception of cartographic conventions or distinct street widths placed on certain lines in a map, the perception extended lines in a map, and the assessment of configurational information of these lines. This is to say that people will first notice whether some lines are wider or have been coloured in such a way that they look relevant (e.g they are painted in red), in order to form an initial idea of these lines´ relative importance in the network. Although these processes are automatic (they are visual processes of pre attentive nature), they are at the same time non-innate mechanisms, meaning that they have had to be learned at some point by people.

The second process, which is also of a pre-attentive character, consists in the identification of longer paths in a map. A crucial role in such process is played by the Gestalt`s principle of Good Continuation (Köffka1935,Köhler1947), which enables individuals to ignore slight turns occurring to streets, so to construct larger and sinuous paths.

The final process refers to the assessment of the configurational information of long lines. This is probably the key issue in this model, for here it has been argued that, rather than mentally assessing the importance of configurational aspects of these lines as such, what people do is to evaluate to what extent there is a synchrony between metric and configurational factors in these lines. This means that people will consider that line X is a main street if, apart form being a long street within its context, line X is also a well-connected and integrated path.

The model suggests that when persons are asked to retrieve hierarchical information of spatial networks, they will assess these three dimensions in an iterative way, forming mental hypotheses about the relative importance of each path. It will be argued that these interpretations will fall in two main zones. If no contradictory information exists between any of the aforementioned spheres, that is, if the widest or most cartographically salient line is at the same time the longest and most connected and/or integrated one, people`s answers will move into what it has been called their "comfort zone" (see triangle at the centre of figure 9).

Future investigations could improve this model and to study how people`s navigational strategies and expectations change when such synchronization is altered in real-world scenarios, and how minor spatial variations that do not alter a system`s configurational or metric factors affect people`s qualitative judgments of these networks.

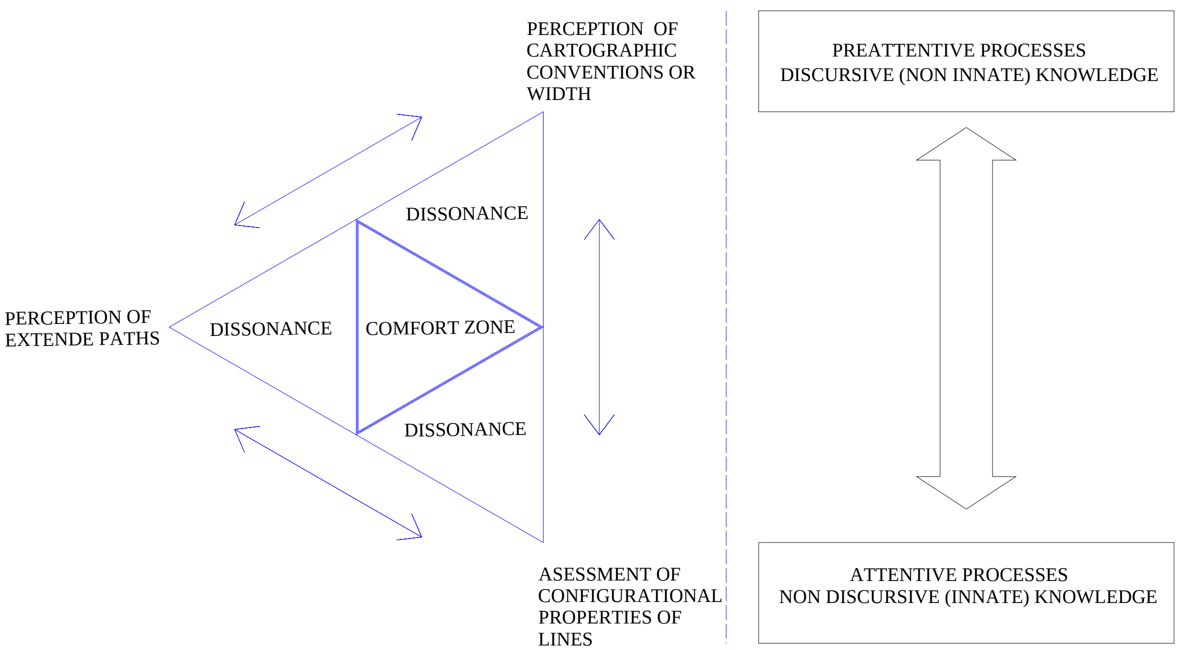


Figure 9: the heuristics proposed in this paper

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