INFORMATIVE MONADS SHAPING
COGNITIVE KNOWLEDGE:
the “urban palimpsest” of Piraeus, Greece

Eirini Rafailaki
University College London

Abstract
This research aims to investigate the local rules and constraints which govern the individual behaviours of the pedestrians of Piraeus, Port of Athens, Greece, by examining the relationship between the spatial syntax of mental representations and the spatial syntax of the environment. The overlaid urban grids of the main city create a “palimpsest” on which the mental spatial models of the users are constructed. Invoking three different criteria, three experiments were conducted in the city’s key-locations. The first criterion concerned people’s access to spatial information (target locations that are out of sight vs. locations with visual access). The second and the third criterion concerned the types of the reference systems; egocentric vs. allocentric and global vs. local scale respectively. The configurational, geographical and topological characteristics of the peninsula provide rather an ambiguous sense of the ease or difficulty of the cognitive understanding of the site. Using syntactical tools of space syntax methodology and descriptive statistics in the experiments, the close relation between the concepts of intelligibility, spatial configurations and visuo-spatial representations is demonstrated. The information provided to the pedestrians has an impact on their wayfinding and navigation processes. It is concluded that the cognitive knowledge of the pedestrians of Piraeus is created, transmitted and applied by the geometrical forms of the city, the morphology of the local visual field – which involves issues of configuration and scale of a space layout – and by topological relations. The most ancient grid, although it contains the elements that have shaped the city's contemporary urban space, it is not easily recognisable by “strangers”; it is mostly found in “inhabitants” internal representations. On the contrary, the elements from the modern times are more frequently cited and they appear to dominate the cognitive model of all users.

Introduction
From the moment we enter the world, we interact with it and we construct mental schemes of that world and our own place in it. The effectiveness and the efficiency of navigational/wayfinding performance involve precision and comprehensiveness of knowing “where we are” (i.e. orientation) and they are determined by individual’s spatial cognition.

Keywords:
Spatial cognition
Wayfinding
Cognitive maps
Allocentric
Egocentric
Space syntax

Eirini Rafailaki
University College London, 1-19 Torrington Place, WC1E 6BT, UK
ireneraf1@yahoo.com
This paper investigates the relationship between the spatial configuration of the physical environment of the centre of Piraeus, the port of Athens, Greece and the spatial cognition of its users; the latter are the Locals, the Regional Locals (partially “strangers”), and the Visitors. It is claimed that the different groups adopt different frames of reference and incorporate different elements in constructing mental spaces for the real spaces of the city.

What follows is a brief theoretical review related to how people cognize the built environment while navigating through it and what kind of “information” they may retrieve and use in a wayfinding performance.

**Literature Review**

**The City as a “Palimpsest”**

The city of Piraeus situated in the northern part of the west coastline of Attica peninsula has been inhabited since about 2,600 B.C. Due to the protection that is provided by the city’s location and the geomorphology of its three natural harbors (Zea, Kastella and the Main Port) and its proximity to Athens, Piraeus, since 5th century B.C., was established as the major naval and commercial port of Greece. In 470 BC, Hippodamus of Miletus', who suggested that the layout of a city could express social order and be rational and geometrically clear, employed the grid-pattern in the design of the city around the original sea – port.

The fully informational through history environment is constructed in multidimensional terms. For B. Lawson “spaces form important constituent parts of what we might call the ‘settings’ in which we behave” (Lawson 2001, p. 35). However, as each city is a “mosaic of social worlds” (Park 1952, p.196), these behavioral settings comprise both the physical and the social environment. In this way, the city of Piraeus could be characterised as a “palimpsest” of urban grids, a multi-layered record of streets, squares and passages that are being explored by the everyday pedestrians – both inhabitants and visitors. The pedestrians read it “as a text but, crucially they also write it” (De Certeau 1984, p.93). When people navigate through this “palimpsest”, they create and simultaneously receive multiple cues that use for updating their spatial position and orientation. Thus, the long history of the city that intervenes is understood as a collective, historical equilibration where the encoded “information” of the city (topographic coincidences, architectural heritage, archaeological findings, the historical importance of specific sites, patterns of public space, legends and local myths) – the genious loci – lies in the identity of the place and its physical features.

**Spatial Cognition, Wayfinding Performance and Navigation Process**

To find the way from one place to another is a task that involves the act of traveling from origin to destination plus the act of spatial problem solving. Therefore, the task encompasses a person’s cognition of the environment; cognition of the different spatial components of the “palimpsest”, in order to use them for updating the spatial position and orientation.

Spatial cognition concerns “the study of knowledge and beliefs about spatial properties of objects and events in the world. Cognition is about knowledge: its acquisition, storage and retrieval, manipulation and use” (Montello 2001, p.14771). Spatial knowledge changes over time, through processes of learning and development. The acquisition, the development and the application of knowledge establish different
movement behaviour, and therefore discrete approach in a wayfinding task.

The human reasoning and decision-making involved in spatial behaviour has gained insight from the work of Kevin Lynch (1960), who argued that “images” of cities guide people’s behaviour and experiences of those cities. Lynch is also attributed to be the first who used the definition of wayfinding as based on “a consistent use and organization of definite sensory cues from the external environment” (Lynch 1960, p. 3). For him, five distinct elements in the city, Paths, Edges, Districts, Nodes and Landmarks, are wayfinding “devices”.

Human wayfinding research investigates the processes that occur when people orient themselves and navigate through space. Wayfinding is the cognitive element of navigation while locomotion is the element that drives the power of moving. The combination of both entails navigation through space. Many theorists try to explain the term “wayfinding” which has different and often complicated definitions (Arthur and Passini 1992, Norman 1988, Gaerling et al. 1983, Weisman 1981). A definition that seems to satisfy all aspect of the task is the following: “Wayfinding is the act of traveling to a destination by a continuous, recursive process of making route-choices whilst evaluating previous spatial decisions against constant cognition of the environment.” (Conroy-Dalton, 2001).

Although many cognitive theories of space influential in the built environment emphasize the position of the subject at the centre of the map, in the cognitive neuro-science the distinction between allocentric (object to object) and ego-centered (body to object) models of cognition is a crucial matter. The allocentric navigation enables humans and animals to generate an internal representational system based on the Cartesian or Polar coordinates of the environment. (Klatzky 1998). The egocentric navigation (the origin is at ego) implies using other available information such as internal cues, motor input, vestibular and directional information.

Mental Representations and Cognitive Maps

The spatial syntax of the environment consists of properties that include location, size, distance, direction, separation and connection, shape, pattern, and movement. Using the spatial syntax, people form mental representations of the spaces whether from navigation or from maps or from descriptions or from a combination, that allow them to arrive at their destinations and to give directions to others with some success. Coined by Tolman in a 1948 paper to refer to internally represented spatial models of the environment (Tolman 1948), these internal representations are called “cognitive maps”.

The Experiments, the Participants and the latter’s Spatial Knowledge

This research suggests that the three groups of people – Locals (the “inhabitants”), the Regional Locals (the partially “strangers”, those who live around Piraeus and they visit it frequently) and the Visitors (pure “strangers”, predominantly tourists) – transmit, interpret and apply the cognitive knowledge in a different way, constructing distinctive cognitive maps that they use while they navigate through the city. Each group is using different kind of spatial knowledge, related to the degree of familiarity they already had with the place they were walking. Following Montello’s classification (2001) it could be claimed that the Visitors of Piraeus have the most basic form of knowledge, the landmark knowledge; the Regional Locals have the route knowledge, which implies that they should be able to find the way to a destination, and, after elaboration, to find the way back (Schachter & Nadel 1991;
Siegel & White 1975). They should also be able to give judgments of directions on the route and estimates of distance and they are half-familiar with the place. Last, the Locals, as they are fully familiar with the environment, have survey knowledge, knowledge of two dimensional layouts that includes simultaneous interrelations of locations (Thorndyke & Stasz 1980). The application of survey knowledge should enable a person to find new ways. This last and more progressed stage (Montello 1997) is the one where the knowledge simultaneously embraces more locations, their interrelations and allows for detouring, shortcutting and creative navigation.

The research consists of three experiments that were conducted in the city centre. The locations that were selected are key-locations (geographically) to the city since ancient times; First, Peraiki Coast inscribes the peninsula, second, Mikrolimano is one of the most important destinations for the city and third, Sotiros Dios St. is located in the pivot point of the flatter central part of Piraeus' oldest regular grid and today is the most important commercial pedestrian street of Piraeus.

In order to investigate the hypothesis in a complete way, different criteria were used so as to define the experiments. The first criterion concerned the access to spatial information (target locations that are out of sight vs. locations with visual access). The second and the third criterion concerned the types of the reference systems; egocentric vs. allocentric and global vs. local scale respectively. Taking every classification into consideration, the following diagram (Figure 1) could be drawn in order to clarify all the above terms within the context of the research.

![Figure 1: Diagram that shows the spatial knowledge and the different criteria for all groups](image)

<table>
<thead>
<tr>
<th>Locals</th>
<th>Landmark Knowledge (Egocentric navigation) local scale</th>
<th>Route Knowledge (Egocentric navigation) local scale</th>
<th>Survey Knowledge (Allocentric navigation) global scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regional Locals</td>
<td>√</td>
<td>√</td>
<td></td>
</tr>
<tr>
<td>Visitors</td>
<td>√</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

--- Experiment 1: Landmark + Route Knowledge
--- Experiment 2: Survey + Landmark Knowledge
--- Experiment 3: Route + Survey Knowledge

**Research Methodology**

The methodology of this research is based on the syntactical tools of space syntax and the statistical tools of descriptive statistics. In recent studies linking space syntax with cognitive science, it has been claimed that the spatial configuration encourages or impedes aspects of human activity through spatial cognition and subsequent movement behaviour (Hillier 1996a; Kim & Penn 2004). In this research, Space Syntax's analytic methods (axial, segment, visibility graph and isovist analysis) are used in order to analyze the qualities of the spatial configuration of the centre of Piraeus. Furthermore, the significant correlations between attributes of its spatial configuration and the observed pedestrian movement patterns are supported statistically through various statistical methods. Mean averages, deviation averages, the central limit theorem and the z-test are the some methods that have been used.
The Experiments

Experiment_01 – Peraiki Coast

The first experiment was conducted in the coastal zone of Peraiki, in the area indicated by the remains of the ancient Konon Walls (393 B.C.), thus allowing abundant visual information for perceiving parts of the ancient fortification system, but not for the rest of the city. The questionnaires were given to a sample of 85 people (31 locals, 27 regional locals, 27 visitors) during a weekday and a weekend. The questionnaires included a layout in which the zone was divided into 6 parts (A, B, C, D, E and F), according to the geomorphology of the coast (Figure 2). Given a diagrammatic map of the coast, participants were instructed to point the location they believe they were and the reasons of certainty. They were also asked the frequency of visit and the degree of certainty of their answer.

Comparing people's perceived location with their actual position, a high degree of deviation is highlighted. Locals' memory appears to be by far more precise than that of Regional Locals'. The latter group, although it uses knowledge, based on travel routines that connect ordered sequences of landmarks, and it is half – familiar with the Coast, it appears to give the least accurate answers to define their location, even in comparison to the Visitors. The results showed also that movement behaviour could be affected not only by visual cues, such as Landmarks, but also by environmental features such as the configuration of the coastline or the distance and time of walking estimation. Furthermore, wayfinding performance is appeared to be aided by maps. To a considerable degree, the maps determine the extent of a subject’s knowledge of its environment.

From this egocentric experiment, the results showed that there were some systematic errors (distortions) in participants’ answers. A great amount of participants, that actually appeared to invoke the Natural Environment as indicator of their location, tended to confuse certain locations. The most frequent confusions were between locations D/E, B/D, B/E and C/E.

The division of the coast into 6 parts was made in order to analyze the syntactical (configurational) and the geometrical properties of Peraiki. Processing an axial break-up of the centre, the Global Integration

Figure 2:
Map of the peninsula that shows a) Piraeus, Fortification Walls (Date: ca. 480 B.C. - 390 B.C.) and city planning from Hippodamus (plan copyright N.D. Papachadzi 1974 98-99 and b) the 6 parts that the coast was divided (A, B, C, D, E and F)
values explain the confusion between C/E and between B/D as the configurational similarities of the parts of the coastline entail error in the correct estimation of self-location. However, the confusion that is caused when people navigate in locations D/E and B/E could be investigated through the geometric properties of the Coast with Visibility Graph Analysis. Several interesting properties of the isovist like the Isovist Area (Figure 3) and Maximum radial length were taken into account in order to draw conclusions about the observed confusion in self-location.

**Figure 3:**
VGA – The measure of Isovist Area (the red color denotes the maximum value and blue represents the minimum value of the measure)

**Experiment_02 – Mikrolimano**

The second experiment was conducted in the harbour of Mikrolimano, in the area below the Hill of Kastella. This area was selected because the height of the hill above obstructs the visual information towards the centre of the city; thus, the experiment’s destinations were out of sight. The questionnaires were given to a sample of 67 people (20 locals, 27 regional locals and 20 visitors) during a weekday. The participants were asked to point out three groups of certain Landmarks of Piraeus: Antiquities, Modern Piraeus and Leisure. In order to avoid any confusion and errors, a compass was used by the researcher during the experiment. The participants were also asked the frequency of their visits and the degree of certainty they accorded their answer.

This experiment had a binary character: the participants had to utilize both egocentric and allocentric representations in order to respond. The latter had to rely on egocentric information in order to point out from their location, but they had to use also allocentric information in order to solve this spatial task, as the target-locations were outside their visual field.

The analysis showed that for an individual to determine a place’s location includes the encoding of both distance and direction which are easily subject to great error. Through the observations, the majority of the Locals having a more complete mental map of the city, they were emphatic about the location of the requested places. Often their mental representations were related to the cardinal compass directions: North, South, East, and West and therefore they were
convenient labels to define the places. The degree of certainty about the position of a place was much greater than the equivalent certainty of the Regional Locals. Last but not least, the Visitors answered with high accuracy but the range of their knowledge regarding the requested locations was extremely limited. The following Polar Charts demonstrate the Directional error for Landmarks concerning Modern Piraeus with associated certainty for all three groups of participants (Figure 4). Each Chart consists of two circles; the outer depicts the answers that were recorded as “certainty” and the inner the answers that were recorded as “uncertainty”.

**Figure 4:** All groups - Directional error for landmarks "Municipal Theatre", “Train Station of Piraeus" and "Naval College" of Modern Piraeus with associated certainty

---

**Experiment_03 – Sotiros Dios St.**

**Part one – mental maps**

The third Experiment was conducted in Sotiros Dios Street with a sample of 76 people (17 locals, 19 regional locals and 15 visitors); it took place during two weekdays and a weekend and consists of two parts. The first part concerns the construction of mental maps and it is an allocentric type of representation. The participants were given a map of the centre of Piraeus, on which no elements were indicated and they were asked to draw a sketch map of the spatial layout of the centre. As through the experiment the frequency of the occurrence of the city elements was substantial to be measured, no instructions or guidance was provided to the sample. A wide range of competence in drawing maps was found among the participants. Figure 5 show a relatively well drawn sketch map.

**Figure 5:** Mental map drawn by a Local
From the analysis of the maps, it was found that there are several typical errors, including incompleteness, variations in scale across the area, roads being drawn too wide, possible straightening of roads and use of single lines to represent streets. The maps are also sometimes very simple, highly selective, distorted, and augmented.

In this part of the research, three techniques are used to elicit cognitive information from the maps. First, a conventional analysis is performed by disaggregating depicted elements. The Lynch-defined environmental components are invoked in order to classify the elements of Piraeus. The number of times each element was drawn is counted (Table 1). The result suggests that the visual descriptor of Landmark (Conroy Dalton & Bafna 2003) plays the primary role in the acquisition and transmission of knowledge of the environment (and not the visual descriptor of Edge). Additionally, the spatial descriptor of District is utilized as an anchor for location in the process of wayfinding.

<table>
<thead>
<tr>
<th>Most frequent in occurrence Elements</th>
<th>Classification</th>
<th>Percentage of occurrence (%)</th>
<th>No of subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main Harbour</td>
<td>District</td>
<td>7.96</td>
<td>37 people</td>
</tr>
<tr>
<td>Municipal Theatre</td>
<td>Landmark</td>
<td>4.52</td>
<td>21 people</td>
</tr>
<tr>
<td>Passalimani</td>
<td>District</td>
<td>4.09</td>
<td>19 people</td>
</tr>
<tr>
<td>Mikrolimano</td>
<td>District</td>
<td>4.09</td>
<td>19 people</td>
</tr>
<tr>
<td>Sotiros Dios St.</td>
<td>Path</td>
<td>3.01</td>
<td>14 people</td>
</tr>
<tr>
<td>Train Station</td>
<td>Landmark</td>
<td>2.80</td>
<td>13 people</td>
</tr>
<tr>
<td>Archaeological Museum</td>
<td>Landmark</td>
<td>2.58</td>
<td>12 people</td>
</tr>
<tr>
<td>My House</td>
<td>Landmark</td>
<td>2.15</td>
<td>10 people</td>
</tr>
<tr>
<td>Korai Sq.</td>
<td>District</td>
<td>1.94</td>
<td>9 people</td>
</tr>
<tr>
<td>Ag. Nikolaos</td>
<td>Landmark</td>
<td>1.94</td>
<td>9 people</td>
</tr>
</tbody>
</table>

In further analysis, Space syntax analysis is applied and an axial break–up that contains all the axial lines which enclose, or are adjacent to, the aforementioned elements was drawn. Therefore, the resultant “set” of the axial lines is held, in statistical terms, to be a “population”. This population consists of 963 axial lines. Furthermore, the ten most frequently occurring elements are chosen and in statistical terms these are held to be a “sample” of the wider “population”. The sample consists of 91 axial lines (Table 2).

<table>
<thead>
<tr>
<th>City Elements</th>
<th>Number of axial lines</th>
<th>Average Int Rn</th>
<th>Average Int R3</th>
<th>Average Connectivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main Harbour</td>
<td>28</td>
<td>1.5837</td>
<td>0.5885</td>
<td>0.2015</td>
</tr>
<tr>
<td>Municipal Theatre</td>
<td>4</td>
<td>0.801</td>
<td>0.8348</td>
<td>0.4345</td>
</tr>
<tr>
<td>Passalimani</td>
<td>10</td>
<td>0.5207</td>
<td>2.5276</td>
<td>0.0976</td>
</tr>
<tr>
<td>Mikrolimano</td>
<td>6</td>
<td>1.0535</td>
<td>0.3677</td>
<td>0.0793</td>
</tr>
<tr>
<td>Sotiros Dios St.</td>
<td>1</td>
<td>2.3881</td>
<td>3.7086</td>
<td>28</td>
</tr>
<tr>
<td>Train Station</td>
<td>4</td>
<td>0.6318</td>
<td>0.7403</td>
<td>0.2916</td>
</tr>
<tr>
<td>Archaeological Museum</td>
<td>4</td>
<td>0.6665</td>
<td>0.8265</td>
<td>18.5</td>
</tr>
<tr>
<td>Peraiki Coast</td>
<td>28</td>
<td>0.1968</td>
<td>0.3809</td>
<td>0.0697</td>
</tr>
<tr>
<td>Korai Sq.</td>
<td>4</td>
<td>0.8043</td>
<td>0.8326</td>
<td>19.25</td>
</tr>
<tr>
<td>Ag. Nikolaos</td>
<td>4</td>
<td>0.6008</td>
<td>0.7795</td>
<td>0.3511</td>
</tr>
<tr>
<td>Total</td>
<td>93</td>
<td>1.5602</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Thirdly, as one of the main objectives of the research is to investigate the association between configurational features and cognitive representations, descriptive statistics were again applied. Using the central limit theorem and the z-test, it is possible to compare the sample of the selected axial lines to its population and determine how likely it is that the sample was drawn at random from that population.
The central limit theorem states that for any sample population drawn from a population (which need not be normally distributed) then as long as the sample size is relatively large (n>10) then the distribution of the sample will be approximately normal. The larger the size of the sample the better the approximation.

The value of the random variable z using the central limit theorem is shown below (Logan, Mallows, Rice and Shepp 1973):

\[
Z = \frac{\sum_{i=1}^{n} X_i - n\mu}{\sigma\sqrt{n}} \sim N(0,1)
\]

Where \(X_1, X_2\), are a sequence of independent random variables (the selected elements), \(\mu\) is the mean of the population and \(\sigma^2\) its standard deviation.

Using the statistical method of z-test, we tested the initial hypothesis which assumed that the pedestrians don’t randomly select the 10 certain elements to represent in their mental maps. The test requires stating a hypothesized mean difference, which in the hypothesis has a value of 0.7031. A confidence level is also required for this test and the standard 95% confidence level has been used. Essentially, if the resultant value of z is less than a specified value (listed on a statistical look-up table), then the “sample” could have been drawn at random from the population. If the value of z is larger, then it implies that participants were not depicting certain elements randomly.

The two tests were made three times (with different number of lines in the sample).

The results of the two statistical tests, the z-test and the central limit theorem, for the three cases are presented in Table 3.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Case1</td>
<td>InRn 91</td>
<td>1.5579</td>
<td>0.3080</td>
<td>0.0949</td>
<td>1.5602</td>
<td>0.5255</td>
<td>0.2762</td>
<td>-22.8363</td>
<td>0.00001</td>
</tr>
<tr>
<td>Case2</td>
<td>InRn 91</td>
<td>1.5579</td>
<td>0.3080</td>
<td>0.0949</td>
<td>1.8647</td>
<td>0.5295</td>
<td>0.2804</td>
<td>-41.5767</td>
<td>0.00001</td>
</tr>
<tr>
<td>Case3</td>
<td>InRn 26</td>
<td>1.5579</td>
<td>0.3080</td>
<td>0.0949</td>
<td>1.8647</td>
<td>0.5295</td>
<td>0.2804</td>
<td>-77.7825</td>
<td>0.00001</td>
</tr>
</tbody>
</table>

According to the results of the z-tests, in all cases the sample of the elements was not drawn randomly from the population. The results of the values of global Integration demonstrate that the cognitive model of Piraeus is constructed in relation to the closeness or accessibility of spaces from all others – in other words the measure of integration.

Analyzing the syntactic properties of the population with a respect to the syntactic variables of the spaces represented in the maps using axial-analysis methods, it could be suggested that not all the depicted elements are located in areas of high connectivity or high integration. Figure 6 shows Global Integration Rn of axial analysis of the “population” and the locations of the “sample” (91 lines).

In order to construct a picture of the ease or difficulty with which we come to understand the shape of this complex space by seeing a part of it at a time through movement within it, the concept of “intelligibility” (Hillier et al. 1987, Hillier 1996a) is built on this relation. The scattergram demonstrating the systematic relation between grid structure and movement, (the correlation between the connectivity and integration values of the lines making up the axial map of the grid,
i.e. intelligibility), reveals that the “sample” has an ambiguous performance within the whole system. The adjusted r-square value 0.5066 implies that the sample is oscillating between intelligibility and unintelligibility. The ten lines that seem to have the best performance are those that “grasp” the three grids of the city and especially the oldest of all grids; that of the centre (Figure 7).

Figure 6:
Global Integration Rn of axial analysis of the “population” and the locations of the “sample” (91 lines)

Figure 7:
Axial Map of the selected “Population”. The most intelligible lines of the “sample” are highlighted. The three grids of the city of Piraeus are clearly demonstrated

Part two – origins-destinations
In the second part of the Experiment, route-choice decisions are made by the participants. As the routes are built up by connecting a series of landmarks, this strategy is egocentric (dependent on the body’s location and direction of pointing in space). The subjects were requested to name the route that they would choose going from a certain origin to a certain destination. This question was made for four
pairs of origins-destinations which were chosen in that way that the elements were distributed within the city centre.

For the research, the route of each subject is represented and analyzed individually. Figure 8 demonstrates the route choices made by all groups from Korai Sq. to Marina Zeas.

Using a Common Lisp application (the SEGMEN model) developed by Iida S., certain routes may be calculated by assigning three different weights to relations between adjacent segments: metric length, directional change, and degree of angular change. In this way, taking the urban street network of Piraeus and subject it to different mathematical interpretations according to how distance is defined, we could be able to explore how well the different interpretations correlate with the real movement patterns taken from the experiment.

Axial and Segment analysis in the axial break – up was carried out in order to measure the syntactic characteristics of the participants' routes. The results show that Locals would find their way through the most integrated lines of the system, while Regional Locals and Visitors would perform wayfinding following the coastal line of Passalimani and Freatida.

Considering both the regression analysis and the route choices of the participants, it could be stated that that the route choices made by subjects appear not to be random, as there is a series of cognitive mechanisms that is involved in producing directions. First, the participants had to activate an internal representation of Piraeus in which the imaginary routes was to be executed. These representations included topographical information and visual aspects of the environment. Afterwards, the participants had to define the route that best fitted the request within the subspace of the currently activated mental representation. The optimal route (in terms of economy of movement) is a straight line (Denis, 1997). Indeed from the observations, many of the most popular routes are very “linear” and many of the least popular routes appear to be very undulating. What is highly interesting is that most of the participants (especially...
Regional Locals and Visitors that have low degree of familiarity with the place) didn’t follow straight routes to the wayfinding goal as SEGMENT analysis highlighted. Only Locals tend to find their way through as a straight a route as possible with minimal angular deviation (from a straight line on condition that this choice always approximately the direction of their final destination. This implies that not only the regularity of the grid contributes to route choice decisions, but the presence of physical obstacles in the environment plays a crucial role. The greater “obstacle” is city’s topography which is rich in height variation, especially in the peninsula. The participants had to consider both topography and the physical constraints (for instance, urban routes must follow the network of streets).

Discussion

Through the research it became evident that the spatial knowledge of the individuals passes through stages: from egocentric to allocentric frames of reference and from topological to fully metric comprehension of space. Defining primary in the body to object relation (egocentric) and then the object to object relation (allocentric), the users construct different models of cognition. First, recorded data from Recognition Tasks in Peraiki Coast showed that although people navigating receive multiple cues for updating their position and orientation, it is the knowledge of both the syntactic and geometrical properties of the coast that have to be subconsciously considered in order to find their way.

Secondly, the findings from the experiment in Mikrolimano, following Moar and Carleton’s (1982) who claim that when people are quite familiar with an environment (as Locals), their pointing accuracy increases enough to allow projective convergence to give an approximate location for the object being pointed to. As pointing is the externalization of cognized directions, the experiment revealed the degree of individuals’ ability to integrate lists and procedures into a configurational knowledge structure. The greatest pointing errors have been compiled by Regional Locals, as their over-confidence entails wrong estimations. In their case, it could be said that “a little knowledge is a dangerous thing” ix. However, is not so clear whether the errors that were made were a result of incorrect distance estimation, incorrect direction estimation, or a combination of both.

Thirdly, the conclusion drawn from the Cognitive Maps was that the depicted features appeared not to be randomly made. These subjective structures that encode the spatial relations “confirmed” the identity of Piraeus as being the “Main Port”. It cannot be discounted that all participants started constructing their maps in relation to the distinguishing geomorphology of the harbors. It has been already suggested that the depicted features appeared not to be randomly made. It can be further suggested that there is not only a close relationship between the spatial configuration in the real world and its representation in spatial cognition (as that can be elicited through cognitive mapping), but also between the spatial component and its significance as part of the “common sense spatial knowledge” which is the knowledge base for most people. This could explain why the frequency with which elements are identified on the cognitive maps is not necessarily highly correlated with all the syntactic measures. Furthermore, the findings from the maps can be linked to the previous experiment’s conclusion, since in both experiments the degree of knowledge of various elements from the different grids of the “palimpsest” was measured.

It is suggested that the most ancient grid although it contains the elements that have shaped the city’s contemporary urban space, are not easily recognizable by “strangers”; they are mostly found in
“inhabitants’ mental representations. The elements from the neoclassical and the modern period of Piraeus are more frequently cited. As the latter two grids contain features that have still a crucial role in the city’s social activities, they appear to be better situated and framed in the cognitive models of Piraeus’ pedestrians.

Fourthly, it can be also noted that Route Choice Decisions (Imagined Movement) made by the pedestrians are also not to be randomly made. People choose strategically certain routes. The route-choice decisions involve a variety of criteria, such as the shortest route, or the route with the smallest angular discrepancy with respect to the goal at each intersection and so forth. The least length, the fewest turns and the least angle change are being taken into consideration (individually or in combinations) when someone tries to find his/her way from an origin to a destination. These route choice decisions that need to be made are related to the kind of cognitive knowledge that a person has.

In conclusion, in the research it was found that the elements which tend to play an important role in people's cognitive scheme are the ones that either have the greatest values in terms of isovists geometrical properties and visibility access or the ones that have the greatest values in terms of axial lines syntactical properties and are located in critical areas which can be considered as landmarks, such as the Town Hall. This research was an attempt to correlate spatial configurations and cognition of the urban environment of the centre of Piraeus so as to investigate the knowledge that urges human behaviour and shapes movement. And that knowledge is a combination of sensation, perception, belief, attitude, reasoning, intentionality, information processing, learning, image, affect, personality, language.

References


Montello, D.R., 1997, NCGIA Core Curriculum in GIS, National Center for Geographic Information and Analysis, University of California, Santa Barbara, USA.


i. Hippodamus of Miletus was the most famous Greek urban theorist, and the earliest of whom we have any real knowledge. (Garland 2001, p. 5).

ii. “Palimpsest”: Etymology: Latin palimpsestus, from Greek palimpsestos scraped again, from palin + psEn to rub, scrape. 1: writing material (as a parchment or tablet) used one or more times after earlier writing has been erased 2: something having usually diverse layers or aspects apparent beneath the surface. Merriam-Webster Online Dictionary copyright © 2005 by Merriam-Webster, Incorporated, viewed 4 June 2006, <http://www.m-w.com/dictionary/Palimpsest>

iii. “Genius loci” is a term literally translated as “spirit of place”, the unique nature of a given site in space. Christian Norberg-Schulz refers to Genius loci as “…that “opposite” man has to come to terms with in order to dwell in a particular place” (Norberg-Schulz 1980).

iv. “The axis of orientation of an object is a line between points on the object that defines a canonical direction in space. Not all objects have an axis of orientation; for example, an object that is radially symmetrical has none. The axis of orientation of a person within a space is aligned with the sagittal plane” (Klatzky, 1998).

v. The experiments were conducted from the 13rd of June until the 23rd of June 2006.

vi. The isovist is the polygon created by delineating the area visible to an observer in that position, most often assumed as having a 360-degree field of vision. Two crucial measures of the isovist that are being discussed in the research are “Isovist Area”, i.e. how much of the environment is visible from any location and “Maximum radial length”, a measure of the "longest available line of sight from an isovist’s viewpoint", (Conroy-Dalton 2001, Ch. 8, p. 158).

vii. The notion of “Landmarks” as spatial reference points was developed (Sadalla et al. 1980) from the concept of “cognitive reference points” (Rosch 1975). The Landmarks are cognitively distinct from other elements in spatial memory and central to the nature and organization of spatial representation (Presson & Montello,1988) As we will show later in the third Experiment, landmarks are the dominant features in the mental maps of the pedestrians of Piraeus.

viii. The “Distance” between lines is conceptualized differently in human navigation, as suggested by Hillier and lida in (Hillier & lida 2005). It could imply least length (metric) where the distance cost of routes in measured as the sum of segment lengths, defining length as the metric distance along the lines between the mid-points of two adjacent segments, fewest turns (topological) where the distance cost is measured as the number of changes of direction have to be taken on a route and least angle change (geometric) where distance cost is measured as the sum of angular changes that are made on a route. The analysis that is performed is simple, constant and metric (angular, topological and metric respectively).

ix. It is an English idiom, meaning that a small amount of knowledge can cause people to think they are more expert than they really are. It was first used by Alexander Pope (1688-1744) - An Essay on Criticism, 1709:“A little learning is a dangerous thing; drink deep, or taste not the Pierian Spring; there shallow draughts intoxicate the brain, and drinking largely sobers us again”. Phrase thesaurus, viewed 8 September 2006, <http://www.phrases.org.uk/meanings/10400.html>.