

Spatial Knowledge in Large-Scale Environments: A Preliminary Planning-Oriented Study

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Abstract. Strategic planning has recently focused its attention on the elements that characterize the spaces through which the agents move, paying particular attention on the way in which they incorporate them. Spatial environments are currently studied from different perspectives, from the cognitivist point of view they represent knowledge-intensive, significant spatial entities to which human agents need to relate adaptively.

The way in which humans use the surrounding space is influenced by a series of implicit factors, such as perceptions, emotions, sensations. These elements, being often tacit, are difficult to identify although they strongly characterize these spaces. For this reason, these characteristics become basic for effective strategic planning at urban and regional level and for environmental decision-making processes.

This study presents a method for quantitatively measuring the reactions of visitors to scenes they encounter in spaces with an extremely small population. We conducted an experiment that required participants to take photographs of elements that caught their attention in poorly structured rural areas. In this way, the photographed features and the related comments have made it possible to better grasp perceptions, sensations, emotions that can represent crucial spatial variables for structuring and interpreting spaces.

Keywords: Strategic planning · Spatial cognition · Open environments · Spatial variables

1 Introduction

Spatial environments are currently studied from different perspectives. From the cognitive point of view, they represent spatial entities characterized by a high density of knowledge to which human agents need to adaptively relate along their life [33]. These environments present an intrinsic complexity that causes complicated problems in planning and management domains [13]. As a consequence, also the interpretation of the agents' spatial behaviors is difficult to characterize and to simulate within artificial intelligence or cybernetic schemes. With regard to this, it is widely recognized that there is a semantic circularity between AI and cognitive science so that the results of research on robotic artificial intelligence devices are fundamental for understanding spatial changes for human decision-making.

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In order to simplify the interpretation of the spatial agents' behavior models, it is necessary to recognize and interpret the features of the surrounding space that affect agents both as points of reference for navigation through spaces and in terms of emotions or perceptions.

Although in literature it is difficult to find a clear definition of the concept of cognitive map and of the processes behind their construction, it is generally agreed that they result from the experience with the environment and the expectations people mature with reference to it.

Cognitive maps creation is the result of very complex processes that may involve verbal instructions decoding, reading maps, images, photographs, or whatever else is involved in our experience with the environment. However difficult changing them once learned may be, the comparison with the world, where correspondence with reality is not recognized, can lead to the addition of new elements or to their appropriate correction [2]. Therefore, despite being recognized as providing conceptual basis for wayfinding tasks, cognitive maps are ill-adapted to the surrounding environment.

In more practical terms of structuring a city cognitive map, Lynch [28] laid the foundation for researching in spatial cognition. Relying on a careful study of the maps drawn by people and on the investigation of the route descriptions, he could define some basic elements: landmarks, paths, nodes, edges, districts. Through these elements he defines the legibility as the ease in identifying physical characteristics in the scheme of a city that help create the image of it our mental representation. According to Lynch [28], the construction of such conceptual models is different from person to person and from task to task.

Recognizing the fundamental spatial characteristics is particularly difficult as it is not always possible to distinguish between substantial and ornamental qualities in the humans' perceptions [18]. Borri and Camarda [6] found that the distinction between "substance" and "ornament" or between "content" and "form" is often unclear in spatial analysis. Day & Bartels, [11] Pouget *et al*. [32] argue that the representation space also changes over time in a way that is not always predictable. For these reasons, the recognition of spatial foundations plays a decisive role in strategic planning.

From the above mentioned, spatial knowledge takes on increasingly interdisciplinary connotations by involving psychology, cybernetics, landscape architecture and engineering environments both on micro-scale spaces (buildings or neighborhoods) and in meso-scale spaces (cities as mixed sets of installed spaces and open spaces) [5, 6]. Researches open interesting perspectives on issues related to conceptual, relational and ontological intelligence but also on orientation problems in indoor and outdoor spaces, on the planning of open spaces and on the pleasantness of green areas.

Although at a macro-scale level space research is still limited [14, 33], studies on the configuration of spaces such as deserts, mountains, forests, oceans, are underway. These spatial conditions extremely complex are comparable to a sort of condition pre-anthropogenic.

In light of the foregoing, we try to study the spatial behavior of agents who move in open and unstructured spaces with extremely small populations, trying to capture the elements that strike their attention. These spaces seem apparently poor compared to urban settlements, so it may be easier to elicit the elements – able to trigger perceptions, sensations, relationships - that influence the user's attention and therefore can be considered as crucial spatial variables.

In particular, we try to analyze the way in which the characterizing features are identified in space during spatial navigation in an open space and to enrich the data information that is gradually acquired. This is also useful in order to identify the elements that can be interpreted as points of reference so that they provide support for navigating such unstructured spaces.

The next chapter provides a research background on spatial cognition, while in chapter three the introduction of the research project structure is presented. Chapter four describes the study we carried out, the methodology adopted and the discussion of some results. The conclusions and an overview of the study outlooks follow.

2 Research Background: An Interdisciplinary Approach

The branch of artificial intelligence focused on spatial cognition pays close attention to the difference between structured and unstructured spaces. The former are characterized by simple geometries - elementary paths, few decisions required, scarcity in terms of furnishings - the latter by numerous articles, composite profiles that require numerous choices to be made or involve unexpected events [10, 16, 23]. Obviously, robots move more easily in poorly structured spaces, being simpler to learn and identify, although recently their behavior is getting closer and closer to human agents' behavior.

Human agents too move more easily in legible spatial layouts that present simple, unidirectional geometries, e.g. a long and empty corridor with doors, windows, skylights lined up. From a logical point of view, they are comparable to a graph arc, with a start point and an end point, without intersections. They require little attention.

Differently it is much more difficult to orientate yourself and navigate through open spaces that offer multiple directions of movement and present a multi-dimensional structure - e.g. a city square - perhaps even more difficult can be the understanding of rural spaces where it is not possible to distinguish the starting/ending points. Although tackle navigation and orientation tasks in spaces with a reduced population is particularly difficult, human agents are able to develop a cognitive map based on the recognition and memorization of points of reference in order to improve the legibility of spaces otherwise incomprehensible [12, 17, 20].

When the information stemming from the surrounding environment is poor, problem arises in identifying the latent variables essential to characterize the space; these variables are extrapolated by human agents to build up the structure of their cognitive map. Knowing that these variables are not easy to identify, the aim of this work is to try to understand, through experimentation on human agents, how these spaces are cognitively modeled.

In fact, it is known that human agents perceive natural elements present in the surrounding environment in a different way and their perception can, in turn, influence the assessments of the surrounding space and human behaviors. A broad body of literature recognizes that some elements of the landscape are preferred by humans; therefore identifying these elements is fundamental for a correct design and management of the environment [25, 40]. On the other hand, preferences are based on the perceptions which are described as a process for understanding sensory information by integrating not only elements present in a scenario but also the unconscious and rapid differences in how space can be used [3, 21, 22].

Understanding how these hostile spaces are interpreted and integrated into the cognitive maps of human agents is also fundamental in shedding light on the navigation strategies they adopt. According to literature in very poor environments, mammals and humans resort to the path integration. The process is triggered thanks to the information coming from our senses through sight, or from our body through proprioception deriving from the movement of the body [23, 24]. Kelly *et al.* [23] claim that in poor environments the absence of external points of reference forces us to refer more to the visual, proprioceptive or kinesthetic flow of information based on perception of the body. Agents assume the initial position and the elements essential to define landmarks. By using this process we are able to construct vectors that are constantly updated along the way [37] in order to provide an estimate of the current position within a larger environment. This continuous updating process for very long paths can result in a demanding cognitive load. Additionally, the absence of significant landmarks significantly worsens spatial orientation because it increases the amount of information to keep in mind.

In this work, we examine the results of experiments conducted with the students of the engineering school of the Polytechnic of Bari. They were asked to walk freely in a rural area and take pictures on what they thought was interesting. Moreover they could add some annotations to tell about their experience. The narration allows them to express the perception of the elements they considered significant. This data is also useful for planners and designers in their decision-making process [19].

This research aimed at identifying which elements characterizing spaces are considered fundamental by users. We tried to do this analyzing the subjects' reactions in order to model the underlying cognitive processes based on the available literature. An attempt has been made to identify a possible correlation between these elements and the perceptions and/or sensations that the agents reported. The resulting data are analyzed in order to trace correlations between the elements present in the protocols collected during the ad hoc experimentation.

3 The Case Study

In 2017, an experiment was carried out with 180 students of the last year of the Urban Planning course at the Polytechnic of Bari were involved. Each student agent freely chose a path in an open rural space. During navigation, they could take pictures of scenarios that attracted their attention. They were also asked to take notes of sensations, perceptions, emotions felt along the way. Route, places of interest and feelings annoted were geo-referenced via smartphone app by each agent, who added his/her profile details on the related online portal.

It has been recently shown that pictures can be used with a high rate of confidence in perceptual studies [19, 21, 35]. The characteristics of the environment are captured through visual experiences, therefore the recognition of elements that have been captured helps understand their experience of space much more than a simple questionnaire. Furthermore, the method offers any participant an immediate and simple way to express the surrounding environment without the need for specific skills [32] allowing, in this way, an immediate identification of essential and latent elements in rural or poorly structured areas.

At present we have carried out a preliminary study, the following analysis refers on a limited sample of 16 out of 180 observations. The statistical work required for the complete analysis of the larger amount of data is currently underway.

Except agent' profile details, the data set is mainly embedded in the kml/ kmz file, from which the quantitative figures are then extracted as strings, texts and graphics (Fig. 1 and 2).



Fig. 1. Example of kmz file: track, photo snapshot and photo locations (Google Earth)

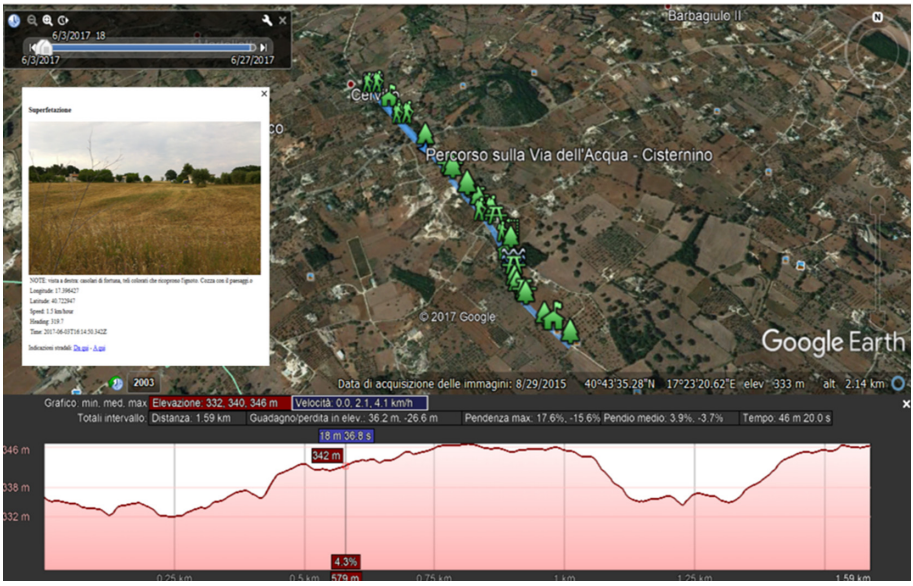

Fig. 2. Example of kmz file: track, levels, snapshot and note locations (icons)

The data mining software Concordance ™ allowed the collection of text annotations in order to calculate the frequencies of word and concept to identify keywords and recognize elements and/or repeats. These are manual ex-post analyzes to aggregate

words into conceptual categories [26]. The ordered dataset is reported in Fig. 3, connected to clusters of conceptual categories specified in Fig. 4.

#	ID	Town of residence	Explored location	Residence-location distance (km)	Min altitude (m)	Level difference (m)	Length (km)	Duration	Buildings	Fauna	Flora	Natural landscape	Dissipation and pollution	Sensations	Plants and installations	Streets	Abstract features	topology
				LUO	ALT	DIS	LUN	TEM	COS	FAU	FLO	PAE	INQ	SEN	TRA	VIE	ABS	TOP
1	552201	Fasano	Cisternino	12	368,2	44,9	1,6	00:46:20	11	3	11	9	4	8	5	5	14	8
2	553745	Bitritto Puglia	Bitonto	15	81	26,7	2	00:42:00	14	1	1	3	4	3	3	5	5	6
3	555252	TRIGGIANO	Carbonara	3,3	41	15,4	0,835	00:41:00	8	1	2	13	14	10	1	3	10	11
4	555512	Laterza	Laterza	6,6	350	48,4	4,3	00:40:00	7	1	1	11	8	3	1	10	7	1
5	566879	Lucera	Lucera	5	192	19,8	2,82	00:26:00	1	1	4	2	1	1	4	4	3	2
6	566927	Rocchetta S.A. (FG)	Rocchetta	1,6	596	76	1,02	00:12:04	12	1	6	6	3	7	2	4	9	4
7	567428	Altamura	Altamura	6	388	23,4	0,8	00:29:00	1	2	2	5	1	4	1	14	1	2
8	567559	Foggia	Siponto	32	1	3	2,31	00:37:00	7	1	3	2	7	13	5	8	4	10
9	567604	Foggia	Segezia	14	134	208	2	00:45:12	3	1	3	5	6	4	9	11	1	7
10	567637	Martina Franca	Chiancaro	1,5	397	423	2,9	00:51:39	14	2	1	10	3	13	1	3	1	9
11	567658	Manfredonia	Amendola	18	34	39	0,617	00:41:00	1	2	14	9	1	11	2	13	11	5
12	567719	Troia	Troia	0,6	1	1	2,29	00:30:00	1	1	1	5	1	1	2	12	1	5
13	567876	Lucera(FG)	Lucera	5	126	30,4	3,42	00:20:33	11	1	5	11	1	1	8	14	2	6
14	570501	Bari	Torre a mare	12	1	4	1,06	00:13:21	4	1	3	3	1	30	3	11	6	7
15	570643	Foggia	Ordona	17	91	9	1,73	00:36:00	1	1	1	1	1	1	1	4	4	3
16	580072	Colletorto (CB)	Colletorto	0,8	571	775	7,9	01:28:49	8	1	5	1	8	12	8	5	8	6

Fig. 3. The complete database

Buildings	**COS**	EDILIZIA, BORGO, MASSERIA, CASALE, COSTRUZIONE, URBANI, CONVENTO, FONTANA, PIETRA, PONTE, CHIESA, EDIFICIO, MURETTI, SILOS, TORRE, VILLA, ABBEVERATOIO, ABITATO, CASA, DEPOSITO, FRANTOIO, PAESE, PORTA, POZZO, TORRI, TRULLO, ARCO, ARCO, CAPANNI, CASTELLO, FINESTRE, MANUFATTO, MARMOREE, MONASTERO, SCALA
Fauna	**FAU**	CAVALLI, INSETTI, ANIMALI, CANI, COLEOTTERO, DOG, FAUNA, VIPERA
Flora	**FLO**	VEGETAZIONE, ALBERI, PIANTA, FLORA, CIPOLLE, ERBA, FICO, FIORE, FRONDE, MORE, POMODORI, VERDURE
Natural landscape	**PAE**	CAMPO, GRANO, RURALE, COLTIVAZIONI, TERRA, ULIVI, VIGNA, CAMPAGNA, TORRENTE, VALLE, AMBIENTALE, AMBIENTE, FLUVIALE, INCOLTO, NATURA, PAESAGGIO, AGRICOLO, AGRUMETO, BUCOLICO, FIUMETTO, PARCO, RACCOLTO, ACQUA, AMBIENTE, ARATURA, CANNETO, FILARI, MONTI, PARK, STEPPA, STERPAGLIA
Dissipation and pollution	**INQ**	RIFIUTI, DEGRADO, ABUSIVISMO, AMIANTO, ECOMOSTRO
Sensations	**SEN**	ABBAIARE, ABBANDONO, ACCIDENTATO, ACRE, AGEVOLE, APPARIVA, ARIA, ARSO, BELLO, BENESSERE, BREVE, BRUCIATA, CALDO, CALMA, COGNITIVA, COLORI, COMODO, CONFONDE, CONTRASTO, DETURPA, DISMISURA, DISSESTATO, DISTESA, EFFETTO, ESALAZIONI, ESPLORARE, FATICA, GRADEVOLE, IMMAGINE, LIBERTÀ, LUCE, ODORE, ORIENTARMI, PACE, PANORAMA, PERICOLANTE, PERICOLO, PIACEVOLE, RISTORO, RUMORE, SCORCIO, SCORGERE, SECCO, SENSAZIONE, SENSO, SGRADEVOLE, SICUREZZA, SPENSIERATEZZA, SPERANZA, STANCHEZZA, SUGGESTIVO, TORRIDO, TRANQUILLITÀ, VENTICELLO
Plants and installations	**TRA**	INDUSTRIALE, PALE, EOLICO, ARTIGIANALE, RECINTO, CANCELLO, ACQUEDOTTO, AZIENDA, DIGA, TRATTORE, ANTENNA, PALI, PANNELLI, PISCINA, TRALICCI
Streets	**VIE**	STRADA, PERCORSO, SENTIERO, ATTRAVERSARE, TRAGITTO, ASFALTO, CAMMINO, STERRATO, RAGGIUNGERE, SEGUIRE, PASSEGGIATA, SALITA, BIVIO, FERROVIA, INCROCIO, SVOLTA, CURVA, RETTILINEO, TRACCIATO, TRAFFICATA, VIAGGIO
Abstract features	**ABS**	VISTA, FORTUNA, INCOMPIUTI, PRESENZA, TRADIZIONI, IGNOTO, NATURA, QUALITÀ, VISTE, ASSENZA, ANTICO, PROSPETTIVA, OBIETTIVO, ILLUMINAZIONE, INTERNO, PARTI, STATO, TEMPO, APERTO, LONTANANZA,
topology	**TOP**	CONFINI, LUOGO, POSTO, RECINTO, TERRITORIO, SPAZIO, INGRESSO, INTORNO, LATO, AREA, ORIZZONTE, PUGLIESE, CIGLIO, LUOGHI, PUNTO, QUI, PARTE, TERRENI

Fig. 4. The clusters of conceptual categories (*Italian excerpt*)

The online web portal of the experimentation is reported in Fig. 5, showing the relevant directions and information for respondents to complete their task.

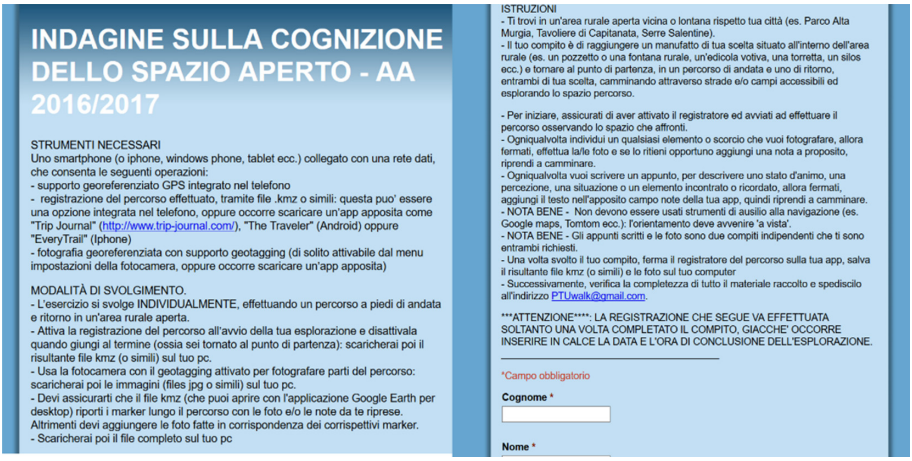

Fig. 5. The web portal of the experimental session (*Italian excerpt*)

The goal of this work, as specified above, is to explore the interconnections between spatial perceptions and/or cognitions of agents and some characterizing elements in the nearby open space.

Regression Statistics	
Multiple R	0,999991784
R Square	0,999983569
Adjusted R Square	0,999753529
Standard Error	0,117466051
Observations	16

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	14	839,7362017	59,98115727	4347,00461	0,01188717
Residual	1	0,013798273	0,013798273		
Total	15	839,75			

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	25,02714273	0,333871773	74,9603434	0,00849225
LUO	0,269964976	0,006949165	38,8485468	0,0163836
ALT	-0,06864833	0,000777872	-88,2514665	0,00721339
DIS	0,126104067	0,000905269	139,3000343	0,00457006
LUN	1,17971297	0,043601742	27,0565561	0,02351852
TEM	-1,32767152	0,01004726	-132,142648	0,00481758
COS	0,522506398	0,017177803	30,41753346	0,02092183
FAU	19,31984334	0,209791355	92,09075045	0,00691269
FLO	-0,71345684	0,029718375	-24,0072629	0,02650248
PAE	-1,32845931	0,023628667	-56,2223559	0,01132206
INQ	2,703984806	0,043864162	61,64451045	0,01032637
TRA	-0,87958957	0,022028729	-39,9292017	0,01594038
VIE	0,556696904	0,011979752	46,46981903	0,01369753
ABS	1,412044889	0,024395856	57,88052263	0,01099777
TOP	-1,73927257	0,04533949	-38,3610974	0,01659169

Fig. 6. The regression output

At this preliminary stage, a multiple regression analysis was used, as an exploratory approach to investigate on possible relations of mutual dependence among variables, while focusing on multiple independent variables at the same time. The aim was to conduct a thorough and mutually comparative evaluation and discussion, made necessary by the small sample analyzed [9].

Using the multiple regression plug-in of Microsoft Excel (Fig. 6 summarizes statistical outcomes); it is possible to sketch out a formal equation as guideline for subsequent considerations.

$$\begin{aligned} Y_{SEN} = {} & 25,02 + 0.27X_{LUO} - 0.06X_{ALT} + 0.126X_{DIS} + 1.179X_{LUN} - 1.32X_{TEM} \\ & + 0.52X_{COS} + 19.31X_{FAU} - 0.71X_{FLO} - 1.33X_{PAE} + 2.70X_{INQ} \\ & - 0.88X_{TRA} + 0.56X_{VIE} + 1.41X_{ABS} - 1.73X_{TOP} \end{aligned}$$

Obviously, being an extremely small sample, it is not possible to infer solid evaluations; however interesting trends and suggestions are deduced. Moreover, the general significance acquired ($R2 > 0.99$) does not overshadow the rather low value in many regression coefficients, as well as the little correlation in absolute terms.

The analysis of the data shows an increase in the sensations and perceptions expressed during navigation directly proportional to the quantitative variation of some characteristics. This could be traced back to the fact that the absence of strong environmental characteristics tends to maximize the likelihood of reliance on egocentric reference systems. The approximation of the current position, therefore, is monitored by self-motion generated signals, such as visual, vestibular and proprioception information. In other words, the more information you memorize the easier it is to relocate your position in the cognitive map.

More particularly, expressions of sensation increase with pollution and resource dissipation appearing along the route (INQ: coeff. = +2.70; $p = 0.01$).

Sensation also sharply increases with the presence of animals (FAU: coeff. = +19.31; $p = 0.007$), probably because of their unexpectedly emerging as singularities on the route.

Chenoweth and Gobster [8] found that aesthetic and sensory experiences tend to activate unexpectedly as a result of interaction with natural objects, even following ephemeral events [31]. Furthermore, it has been demonstrated [39] that the environments that include water, vegetation and animals are the most appreciated among the various scenarios photographed taken by subjects moving though natural environments [36].

Yet sensations exhibit mixed correlations with buildings and artificial features, with coefficients fluctuating around zero value. Agents' sensations increase with the perception of buildings ($c = 0.52$, $p = 0.02$) and streets ($c = 0.55$; $p = 0.01$), while decreasing with plants and installations ($c = -0.88$; $p = 0.01$). In particular, this apparently inconsistent result may be connected to a sample bias. The sample is extremely homogeneous since it consists exclusively of engineering students of a planning course. They are particularly sensitive to evaluating buildings and infrastructure as contextual parts of a wider ecological environment. Their background of studies could naturally induce them to give more emphasis to sensations related to

events/ transformations of which they feel responsible in terms of design (e.g., houses, farms, streets) and to neglect sensations related to the recognition of features considered out of their competence (plants, installations etc.) [4, 34]. On the other hand, the greater attention paid to buildings and streets in a country setting can also be the result of the fact that in the surrounding environment, they stand out as very visible emergencies and therefore they became a sort of landmark in a territory that otherwise would be too homogeneous. In fact, the literature reports that the recognition of a landmark, reducing the uncertainty of those who navigate, could strengthen the accuracy of the path integration.

It is worthy to note that this underestimation does not seem to limit value judgements: in fact, sensations remain positively correlated with dissipating or polluting elements, which are typically involved with physical transformations. Nassauer [30] refer that "taking care" is a typically western cultural phenomenon, widespread, able to trigger an immediate reaction. Care implies participation in the maintenance of landscapes, which results into a benefit for all. It is also known that the sensations reported often reveal the perceived benefits coming from the surrounding environment but also depend on the individual. Furthermore, the perception of the benefit is not static but can change when new circumstances arise [19].

A further seemingly odd result is the negative correlation with the perception of natural landscape ($c = -1.33$, $p = 0.01$), somehow counterintuitive and difficult to be interpreted. Yet literature suggests that usual environments are poorly perceived by agents continuatively acting in that environment [24, 27]. In this sense, natural landscapes are usual environments for students living with their families in lands still traditionally characterized by rural features Therefore, they may be willing and able to describe landscapes that they know quite well, without deriving particular sensations from them. The opposite may be true as well, because agents may be stimulated to the expression of sensations and emotions, yet without describing perceptions about a landscape inherently known [7, 15]. Quite coherently, the flora element ($c = -0.71$, $p = 0.03$) seems to confirm such interpretation, in broad terms.

Subsequently, other elements define the navigation task from a spatial-temporal, geographic and topographical standpoint. For instance, when considering an increasing distance from the agent's residential place ($c = 0.26$, $p = 0.02$) and particularly an increasing route length ($c = 1.18$, $p = 0.02$), then sensations grow as well. It is also likely that this depends on curiosity or the novelty effect for a new environment and for a more changeable environment [29]. However, an inconsistence arises with an upcoming negative correlation with the time required to cover the route ($c = -1.33$, $p = 0{,}005$). This apparent incoherence might be overridden if one considers that a longer time can cause some addiction to perceptions, particularly for a short and not very varied route [24, 38]. On the other hand, in terms of orientation, the fact that the recording of perceptions reduces with the approach of the end of the path could be simply due to the fact that having recognized to be towards the end of the path, on the way back, there was no need to memorize new landmarks or reference points. In other words, because the agents recognized the proximity of the starting point, it was no longer necessary to update the path integration vectors. Furthermore, Sugimoto [36] reports that the frequency with which agents take photos tends to decrease gradually due to the greater tiredness of the subjects and an increase in boredom and fatigue. This

element should not be overlooked as it allows us to understand changes in perception with broader awareness of the environment acquired by users. In any case, the sensations correlate poorly with the dimensional and topographical aspects to the advantage of the contextual and qualifying ones.

4 Conclusions

According to the literature, the way in which spatial elements are rapidly assessed depends on the operating potentiality of the surrounding environment perceived by users. This is true in terms of aesthetic, environmental, legibility and ease of navigation benefits. Some studies have also clarified the validity of the method of analyzing pictures taken by subjects for identifying and understanding the perceptions of users of open spaces.

This study represents a first step in an attempt to grasp the way in which the elements characterizing the surrounding space are quickly identified. The result of the analysis conducted shows a number of interesting and sometimes intriguing, but not significant enough (at least in some cases) suggestions, due to the reduced number of observations and data. In fact, it is purely a preliminary study, still far from adequate research at this stage. However, the pictures taken and the annotations attached provide first indications of the elements characterizing the open spaces that impact the users.

As a matter of fact, many coefficients show low numerical value, so causing the analyzed variables to limitedly affect the dependent variable – that is, the spatial sensations and perceptions of each agent along the route (SEN).

Moreover, the grouping of textual concepts by categories has been carried out using a raw and hybrid approach that may have caused inaccuracies. In fact, while the frequencies of words have been collected and calculated through data-mining tools, words have been subsequently contextualized and categorized using an ex-post manual analysis by the analyst, intrinsically inaccurate.

Notwithstanding these drawbacks and inaccuracies, the overall analysis is able to provide some interesting, at least qualitative considerations. They seem to suggest that the perception of an open space, broadly lacking the structuring elements typically present in confined urban spaces, is still dependent on some recurring physical and landscape features, able to build a cognition-based latent structuring.

Such suggestions prove to be of particular interest in supporting decisions on the management of open spaces. Also, these suggestions are useful in the processes of identification of environmental resources for sustainable community development, as well as for spatial planning aims. If these open spaces are not perceived positively they will not be used even if available. Therefore, it is essential to investigate the perceptions, needs and preferences of users before making decisions on planning open spaces in order to create natural environments that encourage people to use them more frequently. The contact with natural environments, in fact, represents a moment of psychological restoration for those who live in urban areas. In this perspective, it becomes necessary for planners and designers of outdoor spaces to investigate the perception that people have of the attributes of these spaces and their expectations.

Following the present research stage, it seems important that some particular activities are carried out in the next future, particularly aiming at enhancing the robustness and reliability of the analysis, so as to develop more contextual and useful considerations. Firstly, the analysis needs to be enlarged to the entire sample of 180 observations, and/or complemented/compared with further experimental sessions. A second step will be a necessary attempt to integrate the statistical analysis with a probabilistic approach, using inference techniques. This will be aimed at compensating the statistical errors fatally induced by the multiple regression analysis. Furthermore, the sample made up of students from the Polytechnic was extremely homogeneous, it is necessary to repeat the experimentation with various types of participants and make the sample more numerous and statistically significant. In fact, it is known that people of different ages and social, cultural or economic backgrounds perceive natural landscapes in very different ways [19].

As a longer view, the survey carried out here will be further analyzed and complemented using new ontology-based aggregative approaches, increasing used spatial cognition literature [1]. This effort is oriented to the possible building up of spatial models more suitable to deal with the inherent complexity of open environmental system.

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