THE STRUCTURE OF PUBLIC SPACEIN SPARSELY URBAN AREAS

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0 Abstract

The paper reconsiders the question of how visual fields, linear paths and socio-spatial boundaries interact to structure open public space as a field of movement and co-presence in sparse grids.

Keywords. Public space, urban landscape design, visual fields, natural movement, virtual community, housing estates

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1 The question: Sparse grids and the architecture of the urban landscape

In this paper we raise some methodological and design issues relating to the morphology of sparse urban grids, of the sort that have often been associated with modernist housing architecture. For the purposes of our study, sparse urban grids have two main characteristics: medium or high rise buildings are distributed so that a large proportion of the ground remains unbuilt; a clear distinction is preserved between streets and other open spaces.

From the point of view of "space syntax", sparse urban grids raise a fundamental methodological issue: the density of movement, interpreted as the number of people walking along a given axial line, diverges significantly from the density of awareness interpreted as the number of people visible from a given position. The recognition of this problem can be traced in previous work, (Holanda, 1997; Green and Penn, 1997). From a theoretical point of view, sparse grids seem to require us to treat "natural movement" and "virtual community" as distinct variables, conceptually as well as quantitatively, rather that treat them as divergent interpretations of the same phenomenon.

Sparse grids also raise a design problem, namely the relevance of landscaping as a dimension of the architecture of the city. Put simply, if the buildings are treated as constraints over design possibilities on the ground, many alternative morphologies of public space are possible, in contrast to dense grids, where the more conventional street morphology is more or less given. From a theoretical point of view, sparse grids require us to reconsider the structural effects of seemingly weak forms of boundary definition, such as those arising from the layout of pavements, sidewalks, trees, planting and fences. This, in turn, requires us to reconsider the way in which the organizing principles of urban form become intelligible.

2 The project

Housing estates built to accommodate refugees and other economically under-privileged populations in areas which used to be peripheral to the city of Athens, have gradually become absorbed into the metropolitan area. The local authorities are looking for ways to evaluate the future viability of these estates as residential environments. They are also interested in improving the relation of estates to their surroundings so that the inhabitants of the estates are not separated out from other citi-

zens. In this context, they supported an application to the Secretariat of Research and Technology, Ministry of Development, for research funds to study the layout and patterns of public space occupancy in and around the estates. The methodologies of "space syntax" were used in order to look at six estates from the point of view of the theories of natural movement (Hillier et al, 1993) and virtual community (Hillier, 1989). By "theory of natural movement" we refer to the proposition that movement is distributed according to the pattern of integration of a linear representation of layouts as systems of potential movement. By "theory of virtual community" we refer to the proposition that patterns of co-presence and awareness which arise as a by-product of movement and space occupancy constitute a spatially sustained social bond.

This project provided the incentive for reconsidering the broader issues mentioned above. More specifically, it became immediately apparent that the estates stand out from the surrounding urban landscape in two ways. First, they have a recognizable architectural style that could be described as intentional modernism, within a landscape that could be described as vernacular modernism. Second, they are endowed with generous open spaces, within a landscape of very dense constructions. More specifically, public space in most areas of Athens mostly consists of streets and occupies between 15% and 25% of the ground. Public space in the housing estates covers up to 80% of the ground. Much of the public space consists of informal or formal open spaces, planted areas, pedestrian paths, rest areas and small squares.

3 Three housing estates

Three of the estates that we have studied are selected for discussion in this paper (figure 1). The estate at Dourgouti, municipality of Athens, is well linked to the surrounding urban fabric to the North and East, and is bounded by high speed vehicular roads with limited intersections on the West and South. The mixture of land uses around the estate is visible from inside it. Surrounding land uses include a luxury hotel, the headquarters of the Greek Industrial Development Bank, car mechanics and repair shops, and normal neighborhood retail. Shops, restaurants and coffee shops are also located inside the estate, sometimes in accordance to official zoning, and sometimes against it. A major church across the Southern boundary is linked to the estate through a pedestrian overpass.

The estate at Agia Anna, municipality of Rentis, is surrounded by industrial areas and very large urban blocks, so that no pedestrian movement occurs in its vicinity. The Northern and Eastern boundaries coincide with major vehicular arteries, while parts of the Southern and Western boundaries are shared with industrial properties. Some shops, as well as offices are located inside the estate, and additional shops, and coffee shops are located along the Eastern and part of the Southern perimeter. A church is situated across the estate near its Northeastern corner.

The estate at Tavros, municipality of Tavros, is situated between a major road, with commercial land uses on the Southeast, and the railway lines on the Northwest. Surrounding areas are themselves highly fragmented due to the impact of high speed vehicular roads, the railway line, and large industrial properties. A major public institution is located near the estate, to the east, surrounded by another housing estate and a mostly residential neighborhood.

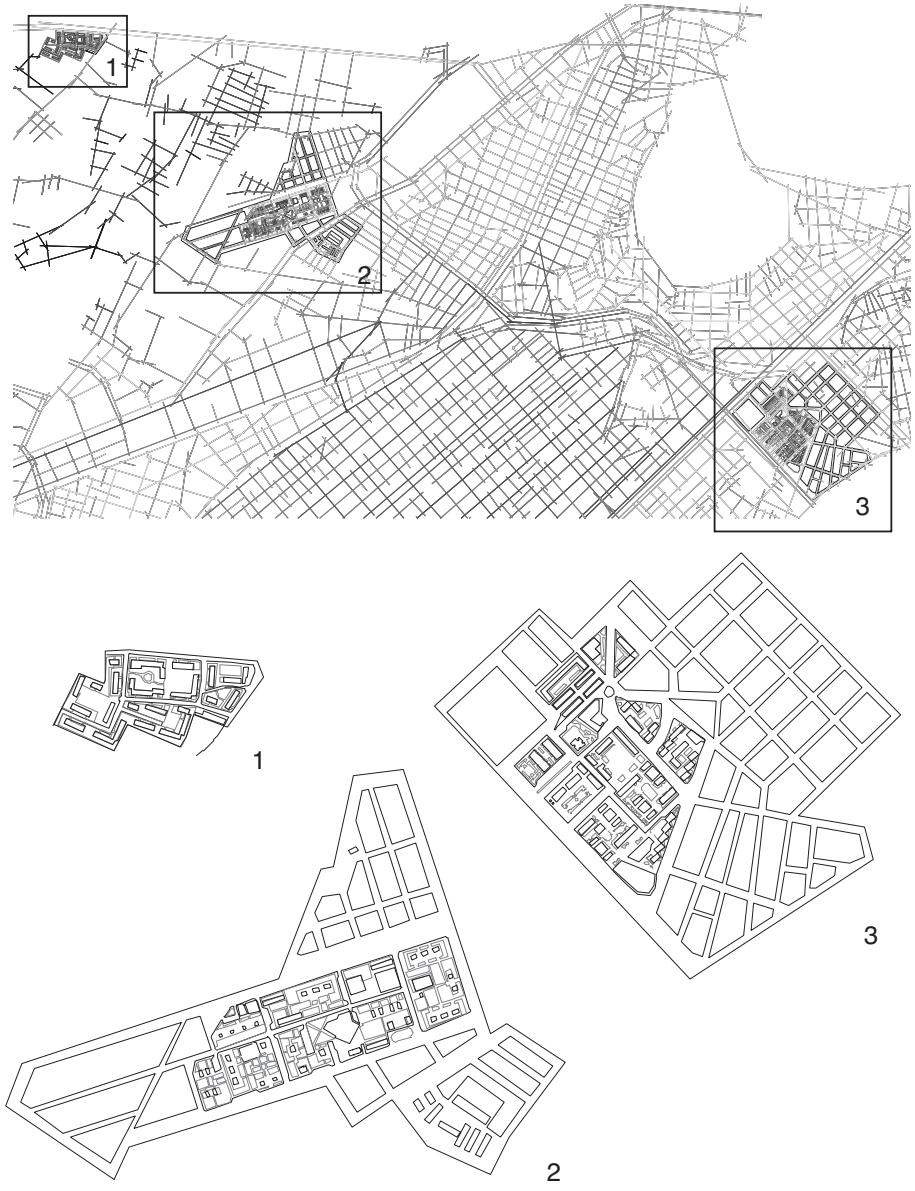

figure 1. Three housing estates in the Athens Metropolitan Area, 1: Agia Anna; 2: Tavros; 3: Dourgouti

The estate at Dourgouti exemplifies the highest degree of apparent blending with the surrounding urban fabric, both in terms of the continuity of streets and in terms of land uses. According to the same criteria, the estate at Agia Anna exemplifies the highest degree of separation from the surrounding urban fabric. Finally, the estate at Tavros exemplifies a peculiar collage of morphologies, networks and land use patterns where no dominant pattern prevails.

4 The field of presence: movement by line and awareness by isovist

The presence of people was observed in all spaces inside each estate. All street segments around the estates were also observed, up to a radius of several urban blocks, in all directions in which no major boundary disrupts the continuity of the urban fabric. Ten rounds of observations were completed. Dot maps representing the presence of moving and static people over the three estates and surrounding areas were created, as exemplified in figure 2. We have used a Microstation platform throughout our work so that "Spatialist" could be used as an analytic tool to deal with both axial analysis and visual fields. "Spatialist" is a set of analytic routines for syntactic analysis recently developed at the Georgia Institute of Technology.

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figure 2. Aggregate space occupancy at Dourgouti (5 rounds of observations). The presence of people reflects the difference between the linear structure of public space in the surrounding areas and the sparse grid in the interior of the estate.

The dots representing moving and static people were first assigned to the metrically nearest axial line, in order to establish the correlation between densities of space occupancy and the syntactic properties of the axial map. The characteristic densities of moving and static people, inside and around the estates are given in table 1. The table provides average figures for all linear spaces, as well as the maximum and the minimum mean densities observed. The data in table 1 support two observations. First, densities of movement and overall presence in and around the estates are low. There are never more than about 2.5 moving people per 100 meters on average and more usually the figure is less than 1 person per 100 meters. There are never more than 5 people present per 100 meters and more usually the figure is about 3. For the sake of comparison we refer to Kypseli, a dense residential area in Athens, where the average number of moving people per 100 meters was found to be 5.344 and the average number of all people 8.845 (Peponis et al, 1989).

Second, estates do not appear to attract much through-movement. More specifically, densities of movement and overall presence increase at the boundaries of the estates. In the two cases where surrounding areas permit pedestrian movement, the densities of movement and presence are, on average, higher in the surroundings of the estates than inside them. Municipal concerns regarding the incorporation of the estates into the ebb and flow of urban life seem well founded.

In order to offer a quantitative description of the field of awareness we studied 20 isovists in each housing estate. Isovists were drawn on a plan representing the outlines of buildings and major boundaries (figure 3). By implication, they under-represent the effects of planting, parked cars and other visual obstacles. We think however, that even these simplified isovists provide a good first approximation to the

Table 1

	M Mean	*M Min*	*M Max*	*S Mean*	*S Min*	*S Max*	*All Mean*	*All Min*	*All Max*
Dourg In 92	.794	0.000	2.897	1.8	0.000	24.13	2.594	0.000	25.286
Dourg Out 30	2.578	0.000	6.327	2.320	0.000	8.234	4.898	.3	14.261
Dourg Lim 6	1.927	.964	3.273	.888	.107	2.905	2.815	1.072	5.602
Dourg All 128	1.265	0.000	6.327	1.879	0.000	24.13	3.144	0.000	25.286
Anna In 32	.547	0.000	2.167	2.599	0.000	30.753	3.146	0.000	30.753
Anna Lim 2	.883	.522	1.243	2.883	2.612	3.155	3.766	3.134	4.398
Anna All 34	.567	0.000	2.167	2.616	0.000	30.753	3.183	0.000	30.753
Tavros In 108	.313	0.000	2.956	.965	0.000	11.472	1.278	0.000	11.472
Tavros Out 35	.992	0.000	2.721	1.879	0.000	16.140	2.871	0.000	18.830
Tavros Lim 4	1.118	0.000	1.992	1.775	.548	4.689	2.893	1.130	6.663
Tavros All 147	.502	0.000	2.956	1.210	0.000	16.140	1.713	0.000	18.830

note: The numbers in column 1 provide a count of the axial lines involved in each condition, inside the estates, in the surrounding area, and at the boundary between the two. Axial lines add up to a total of 16.4, 2.25 and 13.5 km in the Dourgouti, Agia Anna and Tavros areas respectively.

Table 1. Densities of people per axial line in and around three housing estates, Athens Metropolitan Area.

analytic study of the actual visual field. They also provide an accurate representation of the underlying visual field that frames all landscape design which does not involve modification of the main built structures. The roots of the 20 isovists were placed so as to pick up 10 well used and 10 less well used spaces. The characteristic densities of moving and static people per isovist, inside and around the estates are given in table 2. These densities were established by counting the recorded number of people inside each isovist polygon and then dividing by the number of observations. The table provides average figures for all isovists, as well as the figures corresponding to the individual isovists with the maximum and the minimum densities observed. All densities, however, are means from the 10 rounds of observations.

figure 3. Isovists were drawn from densely (1) and sparsely (2) occupied root positions. Virtual community is a function of the number of people animating the isovist field.

Table 2. Densities of people per isovist in three housing estates, Athens Metropolitan Area.

Table 2.

	M Mean	*M Min*	*M Max*	*S Mean*	*S Min*	*S Max*	*All Mean*	*All Min*	*All Max*
Dourg 20	3.78	.2	8.7	6.675	.6	27.4	10.455	.8	35.7
Anna 20	1.625	0.000	4.2	6.625	0.000	16.5	8.250	.723	19
Tavros 20	6.34	1.2	14	11.855	1	26	18.195	2.6	36.9

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The data in table 2 are not readily comparable to the data in table 1 for several reasons. First, the densities by line are expressed as a rate per 100 meters, while the densities by isovist are a straight count. Second, the densities by line are essentially a linear magnitude while the densities by isovist are essentially a two dimensional magnitude. Third, the densities by line are averaged over the entire set of lines while the densities by isovist are averaged over a sample of 20 isovists. The third limitation has to be accepted on pragmatic grounds. To draw all different isovists in a system is equivalent to drawing as many isovists as there are convex spaces in the e-partition. The e-partition (Peponis et al, 1997) identifies all the convex spaces which are informationally stable in the sense that isovists drawn from any point in them cover the same corners and endpoints of the surrounding built shape. This number, however, is extremely large and an exhaustive drawing of all isovists is computationally unrealistic for any complex system such as the estates under consideration. Alternatively, we could come up with a theoretical argument and a procedure for identifying some smaller set of isovists as sufficient to the characterization of a layout in terms of visual fields. Such a task is beyond the scope of this paper. We will accept, therefore, that the systems can reasonably be characterized by a sample of isovists and proceed with the comparison.

In order not to compare a straight count to a standardized rate, we may consider the total number of people assigned to each line inside the estate, whatever the line length. Thus, we can compare two straight counts that refer to the fields of movement and awareness as they become available to the situated observer. In essence, we ask how the number of people that are assigned to the same line of movement as a situated observer compares to the number of people that come into the visual field of that observer. The corresponding figures and ratios are presented in table 3.

Table 3.

	Moving	*Static*	*All*
Dourgouti	3.78/1.564 = 2.417	6.675/3.377 = 1.987	10.455/4.335 = 2.412
Agia Anna	1.625/.447 = 3.635	6.625/1.712 = 3.87	8.250/2.159 = 3.821
Tavros	6.34/.523 = 12.122	11.855/.861 = 13.769	18.195/1.385 = 13.137

Table 3. Ratios of average people per isovist to average perople per line in three housing estates, Athens Metropolitan Area.

The number of people per isovist is clearly higher than the number of people per line of movement. In the case of Tavros, the difference is exaggerated by the fact that buildings occupy a small proportion of the ground: by implication, isovists which do not take into account the limiting effects of vegetation and other visual obstacles stretch over larger areas in a manner which over estimates the actual visual field. Even when this is taken into account, however, we can safely conclude that there tend to be at least twice more people in the visual field than are present on any given line of movement.

The levels of awareness picked up by isovist analysis correspond better to the experience of virtual community in the field. Even though the estates are not characterized by high volumes of natural movement one is always aware of being situated within a field of visual surveillance and a field of encounter, which are all the more evident for the relative low volumes of strangers passing through. The high densities of standing as compared to moving people also indicate the presence of an active local community.

5. The syntactic gravitation of presence: natural movement and visual potential. 53.7

The correlations between Integration and the densities of people per 100 meters of an axial line were studied, in accordance with the theory of natural movement (Hillier et al, 1993) (table 4). We considered three main syntactic variables, Integration, Integration-radius 3 and Connectivity. These were computed on the basis of a large axial map containing all the estates under investigation and covering the portion of the Metropolitan area of Athens between the city center and the city of Piraeus. Thus, the measure of Integration takes into account a large urban area, while Integration radius 3 is more sensitive to the local systems under investigation.

Table 4

Estate	*Var*	*Mov In*	*Mov Out*	*Mov AL*	*Stat In*	*Stat Out*	*Stat AL*	*All In*	*All Out*	*All AL*
Dourg	Int	.285	109	.446	.050	.068	.057	.104	.099	.212
		(.0060)	(.5646)	(.0001)	(.6341)	(.7207)	(.5238)	(.3238)	(.6025)	(.0161)
Dourg	Int3	.561	.295	.577	.209	.234	.193	.310	.298	.378
		(.0001)	(.1133)	(.0001)	(.0460)	(.2123)	(.0288)	(.1026)	(.1100)	(.0001)
Dourg	Con	.540	.336	.565	.246	.253	.205	.342	.331	.383
		(.0001)	(.0691)	(.0001)	(.0179)	(.1781)	(.0201)	(.0008)	(.0744)	(.0001)
Anna	Int	.304	NA	.306	.037	NA	.036	.068	NA	.068
		(.0909)		(.0786)	(.8409)		(.8384)	(.7109)		(.7008)
Anna	Int3	.431	NA	.371	.138	NA	.096	.090	NA	.054
		(.0138)		(.0308)	(.4503)		(.5899)	(.6243)		(.7623)
Anna	Con	.347	NA	.205	.108	NA	.045	.069	NA	.022
		(.0514)		(.2456)	(.5571)		(.8024)	(.7079)		(.9035)
Tavros	Int	.480	.158	.504	.039	.148	.074	.169	.092	.205
		(.0001)	(.3635)	(.0001)	(.6877)	(.3948)	(.3725)	(.0812)	(.5985)	(.0128)
Tavros	Int3	.373	.212	.382	.065	.203	.069	.045	.224	.166.166
		(.0001)	(.2221)	(.0001)	(.5064)	(.2420)	(.4076)	(.6470)	(.1953)	(.0441)
Tavros	Con	.360	.222	.361	.032	.247	.096	.071	.265	.184
		(.0001)	(.1992)	(.0001)	(.7412)	(.1518)	(.2470)	(.4684)	(.1238)	(.0256)

notes: 1) Statistical significance is indicated in parentheses. 2) Correlations are computed separately for lines inside the estate (In), lines outside it (Out), and all lines (AL); lines on the boundary are included only in the set of all lines.

Table 4. Correlations between densities of people per 100 m and the syntactic properties of axial lines in three housing estates, Athens Metropolitan Area

As expected, correlations between the densities of standing people and syntactic variables are weak and tend to be insignificant. Correlations between the densities of moving people and syntactic variables are stronger and reach significance more often. However, they never exceed a value of .577, while the lowest significant correlation is .360. Thus, the correlation between movement densities and syntactic variables is weaker than reported in other studies. In the residential areas of Kypseli, for example, the correlation between movement densities and syntactic integration tends to values around .7 (Peponis et al, 1989).

The correlation between the densities of movement and syntactic variables is better when we consider the interior of the estates than when we consider the streets surrounding them. In fact correlations for the surrounding streets never reach statistical significance. Also, the predictability of movement densities by syntactic vari-

ables increases when we consider the estates and their surroundings as a single system rather than split the sample of lines into internal, external and boundary sub-sets. In other words, while movement in estate areas is not strongly predictable by syntactic variables, the estates themselves seem to contribute to the structuring of movement according to the properties of the urban layout. They intensify, rather than weaken or eliminate the pattern of "natural movement". We think that this finding is linked to the fact that streets extend into and through the estates. The morphological differentiation of the estates from their surroundings is a function of the way in which buildings occupy the ground to create a system of open spaces, rather than a function of interruptions or excessive distortions the underlying grid of streets. We will take this issue up later on.

Integration and Integration radius-3 values were also computed after elimination of all pedestrian paths internal to the urban blocks. This was aimed at enabling us to test whether the axial structure of the street system corresponded better to patterns of presence than the axial structure of the entire open space. The densities of presence along the streets were correlated to the modified measures of integration (table 5). Most correlations fail to reach significance. Of the ones that reach at least a 5% level of significance, 7 are stronger that the corresponding correlations obtained previously, and 3 are weaker. The stronger correlations include a negative correlation between Integration and the density of people moving in streets inside the Dourgouti estate. Taken as a whole, these findings do not allow us to infer that the density of people present in the streets is more closely associated with the linear syntactic structure of the streets rather than the syntactic structure of all public open spaces.

Table 5

Estate	*Var*	*Mov In*	*Mov Out*	*Mov AL*	*Stat In*	*Stat Out*	*Stat AL*	*All In*	*All Out*	*All AL*
Dourg	Int	-.630	.109	.023	.009	.066	.040	-.183	.097	.016
		(.0118)	(.5819)	(.8730)	(.9744)	(.7391)	(.7851)	(.5137)	(.6231)	(.9115)
Dourg	Int3	.102	.344	.398	.378	.284	.233	.388	.352	.358
		(.7163)	(.0734)	(.0046)	(.1648)	(.1437)	(.1064)	(.1526)	(.0659)	(.0115)
Anna	Int	-.104	NA	.011	.433	NA	.309	.356	NA	.270
		(.7904)		(.9754)	(.2446)		(.3857)	(.3469)		(.4503)
Anna	Int3	.391	NA	.387	.687	NA	.444	.668	NA	.459
		(.2978)		(.2687)	(.0410)		(.1982)	(.0492)		(.1825)
Tavros	Int	.305	.172	.180	.043	-.113	-.045	.168	.058	.009
		(.3349)	(.3648)	(.2302)	(.8946)	(.5538)	(.7641)	(.6011)	(.7606)	(.9545)
Tavros	Int3	.394	.253	.306	.070	.358	.327	.226	.367	.356
		(.2053)	(.1773)	(.0383)	(.8294)	(.0520)	(.0268)	(.4714)	(.0458)	(.0152)

notes: Significance is reported in parentheses. Correlations marked by an asterix have been computed after removing from the sample a children's playground with very high density of standing occupancy.

Table 5. Correlations between densities of people per 100 m and the syntactic structure of streets in three housing estates, Athens Metropolitan Area

The theory of natural movement suggests that movement gravitates towards the most integrated lines. This theory is supported by our findings even though the correlations are weaker than the ones identified in other areas. To better understand the spatial logic of presence in public space we proceeded to investigate the effects of visual fields. On the assumption that the pattern of movement and co-presence is distributed throughout the areas under investigation, we expect that larger isovists will cover larger numbers of people. To test this hypothesis we computed the correlation between the area of the isovists and the numbers of people visible (table 5). The correlations are all very strong and significant, thus confirming the hypothesis. We then asked whether isovists that reach more people are also rooted in more densely occupied positions. Also, we asked whether isovists with

greater areas are more densely occupied around their roots. These two questions were aimed at exploring a less obvious hypothesis, namely that the presence of people is biased towards the roots of more populated and larger isovists.

The root density of an isovist was measured by drawing a circle of 20 meters radius around the root of the isovist and counting the people within that radius. The number of people associated with the root was then subtracted from the total number of people covered by the isovist in order to obtain a value for the number of people visible at a distance. The radius of 20 meters is, of course, quite arbitrary. It only serves to make a methodological experiment possible. Our method was applied to moving people, standing people and all people covered by each isovist. Relevant correlations are reported in table 6.

Table 6

	Cor: Area Iso - People			*Cor: People at Root - People Beyond*			*Cor: Area Iso - People at Root*		
	Mov	*Sta*	*All*	*Move*	*Sta*	*All*	*Move*	*Sta*	*All*
Dourg	.797	.805	.848	.569	.503	.685	.348	.636	.711
	(.0001)	(.0001)	(.0001)	(.0088)	(.0239)	(.0004)	(.1324)	(.0026)	(.0004)
Anna	.877	.869	.898	.580	.432*	.562*	.653	.595*	.696*
	(.0001)	(.0001)	(.0001)	(.0074)	(.0649)	(.0122)	(.0018)	(.0072)	(.0009)
Tavros	.832	.866	.9	.491	.277	.529	.439	.315	.409
	(.0001)	(.0001)	(.0001)	(.0278)	(.2374)	(.0165)	(.0530)	(.1757)	(.0732)

Table 6. Correlations of visual fields and patterns of awareness in three estates, Athens Metropolitan Area.

The roots of isovists which cover more people beyond the 20 meter radius are also occupied by more people inside that radius. According to a complementary trend, the roots of isovists with larger areas tend to be occupied by more people. These findings indicate that people are not uniformly distributed over the visual field. Rather, they converge towards the areas which offer greater potential for becoming aware of the animated visual field. The gravitation towards the positions which offer greater awareness of co-presence complements the gravitation towards the most integrated lines. What is more, the effects of the structure of the visual fields are as noticeable when we look at the presence of static people as they are when we look at the presence of moving people.

The results of the analysis indicate that virtual community within the estates is subject to two structuring effects (figure 4). It arises as a by product of movement, which is aligned to the structure of integration of the axial map. It also arises as a by product of occupying populated visual fields. It is intensified at positions from which the visual fields are more expansive and more intensely animated. In dense urban grids the two structuring effects are easily compounded, as visual fields extend in essentially one direction, the direction of movement. Sparse grids force us to distinguish between the two spatial dimensions of virtual community.

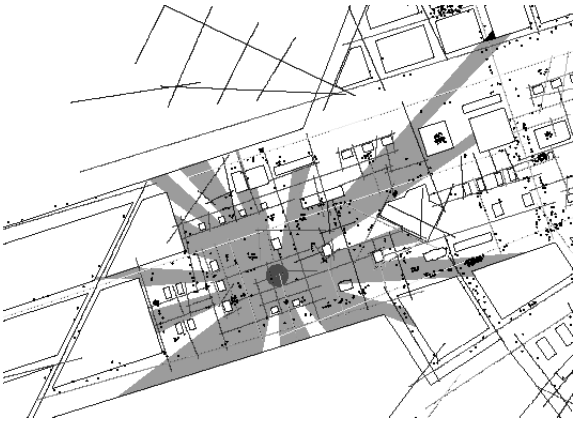

figure 4. In sparse grids there is a strong non-correspondence between the two dimensional animated isovist field, and the linear structure that carries movement (diagram taken from the Tavros estate).

6 The structuring of open space.

Our findings suggest that the analysis of presence in the open spaces of sparse grids cannot fully be understood in the technical terms of the theory of natural movement. The properties of visual fields interact with the properties and axial maps and the density of presence is more powerfully correlated with the former than the later. If our findings are duplicated elsewhere, the analytic statement of the theories of natural movement and virtual community must be re-examined. In this section we would like to discuss some aspects of the modeling of spatial structure that seem linked to the problem. Our argument is to some extent speculative. Our intention at this stage, is to assist the formulation of a question rather than to provide a complete answer.

Uniform open space imposes no restriction upon movement and therefore defines no intelligible syntactic structure that can relate to movement patterns. The only way that we could retrieve a syntactic description of entirely open space would be through the incorporation of metric properties within a syntactic framework, much as Hillier (1996) treats transitions across the units of a two dimensional metric grid as equivalent to syntactic steps across thresholds of spatial depth. As physical boundaries are placed in space, the layout acquires a syntactic structure and imposes restrictions upon potential movement. The fundamental hypothesis of the theory of natural movement is that observed movement densities are correlated to the syntactic structure of the layout. The precise analytic and technical statement of the hypothesis is that movement densities are correlated to the pattern of integration of the system of linear spatial elements that act as the underlying carrier of observed paths. We have suggested that in open systems the properties of the visual field do likewise affect the distribution of presence, including movement. It would appear that when boundaries are sparse, linear elements are poorly defined, potential paths are under-restricted, and the structure of the visual field plays a more important role in deciding how the density of presence is distributed. In dense street morphologies linear elements are well defined, the structure of the visual field varies less, and the pattern of integration of linear elements gets to govern the distribution of density. Such, in outline, would be the theoretical thesis that could be retrieved from our findings, without contradiction to the analytic statement of the theory of natural movement.

A closer examination of the data supports an interesting elaboration of the argument. Structure can be imposed through the creation of boundaries which while not physically limiting movement, institute a socially intelligible carrier grid. The demarcation of public and private property can be treated as an example in places where it is not picked up by a physical barrier,such as the typical residential street with detached houses in cities in the United States. However, socially intelligible boundaries can be created within the domain of public space. The demarcation between the street and other public open spaces is prevalent in the three housing estates under consideration. In our opinion, the fact that the street is not defined as a left over from the dense juxtaposition of buildings does not mean that it is not constituted. On the contrary, the demarcation of the street, and the concomitant demarcation of urban blocks surrounded by streets is constitutive of public space. Put crudely, grass with demarcated streets and sparse buildings is not equivalent to grass with sparse buildings. The issue of whether doors, or windows are open to the street, thus constituting an interface between street and interiors should not be

confused with the issue of whether the street itself is clearly articulated. The importance of these remarks to the theoretical framework projected previously is quite clear. Even in sparse systems, demarcated streets introduce linear elements that can affect the distribution of movement and presence in accordance to the original statement of the theory of natural movement. In short, the demarcated street introduces linear structure into the otherwise two dimensional visual field.

We can further hypothesize that the degree to which the syntactic structure of linear elements situated within sparse systems actually correlates with observed movement densities could plausibly be affected by two factors: The first factor is the way in which the linear elements that cross the sparse portions of the overall system are integrated with the linear elements that run through its denser portions. This can determine whether or not actual movement will align itself to un-demarcated shortcuts rather than demarcated streets. The second factor is the way in which the pattern of integration of linear elements interacts with the structure of the visual field. The second hypothesis, more particularly, is consistent with our finding that movement and presence on streets correlates best with axial integration when we consider streets in conjunction with other open spaces than when we consider them in isolation. We are currently exploring these hypotheses further. Dealing with the second hypothesis is computationally harder. The generation of large numbers of isovists and the analysis of how they intersect to create patterns of integration have not yet been efficiently automated within "Spatialist".

At this stage of our research, what evidence or arguments can we adduce to confirm the importance of the demarcation of streets and urban blocks in a sparse system? We can certainly observe that street spaces inside the estates are much more intensely occupied that the interiors of urban blocks (table 7). In turn, the interiors of urban blocks are more densely occupied when they are open to the street on at least one side, thus effectively acting as squares. In addition, we can speculate that the incorporation of estates within the weak pattern of natural movement is supported by two critical morphological characteristics. First, the streets that run through the estates are continuously linked to the street pattern surrounding the estates. Second, all public open spaces are at most one axial step deep from the nearest street. These chasracteristics are certainly not typical of housing estates which are spatially cut-off from their surroundings and function not as parts of a pattern of natural movement, however weakly realized, but as local eliminations of that pattern.

Table 7

	Mov Streets	*Mov Block Inter*	*Static Streets*	*Static Block Inter*	*All Streets*	*All Block Inter*
Dourgouti	1.726	.657	2.136	1.276	3.861	1.937
Anna	.725	.288	3.386	1.683	4.111	1.971
Tavros	1.284	.226	1.345	.772	2.628	.997

Table 7. Densities of presence on streets and the interior of urban blocks in three housing estates, Athens Metropolitan Area.

7 A constitutive role for urban landscape design

We conclude our paper with the observation that the findings and hypotheses presented above are very relevant to a syntactic assessment of the functions of landscape design. In the estates under consideration several layers of landscape design can be identified. Some tree planting serves to enhance the demarcation of streets in conditions where streets are not continuously bounded by buildings. Such planting complements the construction of pedestrian pavements to create a street archi-

tecture. Some additional planting is used to create a very necessary buffer between the residential buildings and public space. Most other landscape design does not appear to be driven by a consistent architectural or social logic, save perhaps the creation of a "green" imagery and the saturation of open space with disjoint formal events. At times, landscape design picks up the geometry of surrounding buildings. More often it serves to deploy decorative motifs on the ground. Sometimes, landscape design creates a proliferation of poorly used pedestrian paths. At other times, it leads to a fragmentation of potentially strong isovists. We are currently exploring how landscape design could be used to enhance the intelligible structure of open space, to assert its public nature, to create a viable pattern of pedestrian axial lines that can work in conjunction with the existing streets, and to draw the best advantage of the isovist fields. Design proposals are currently under development but some preliminary ideas may be ready for presentation at the conference. Our work supports the idea that "space syntax" can be applied not only to the design of the basic urban grid, but also to the integrated design of open spaces. The further examination of the theoretical questions advanced earlier will strengthen the knowledge base from which such application of "space syntax" can proceed.

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