Street Patterns and Spatial Integration of Israeli Cities

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Abstract
This paper examines the spatial configuration of twenty-four cities that represent the major city types found in Israel, classified according to the circumstances under which they were originally established and developed. An initial analysis has indicated that cities belonging to the same type have broadly similar street patterns, but at the same time they can be distinguished from one another according to the continuity and shape of those networks as a consequence of their different topographical conditions and the ways in which their built-up areas have grown. In this research, several questions were examined, including: is it possible to specify any shared characteristics among the selected examples of Israeli cities; to what extent, if any, do these different city types exhibit underlying common syntactic parameters and patterns of spatial integration; how does the spatial sub-division of each city into islands made up of blocks and plots produce differently-shaped street networks, and how might this process of growth and change affect spatial integration.

The measurement and analysis of spatial integration were conducted using the approach and methods of space syntax. The results that were obtained indicated that cities belonging to the same city type tended to exhibit similar local levels of spatial integration and that this was mainly a product of their street patterns. By contrast, significant syntactic differences appeared at a global level, which were mainly related to the different levels of discontinuity and partitions in their street networks as well as to the overall built form and configuration of the entire street system of each city.

A comparison of the syntactic (spatial integration) values obtained in this research with those obtained for cities in other parts of the world revealed that, in general, Israeli cities were comparable in this respect to U.K. and European cities, although they were characterized by relatively small differences between their mean local and global spatial integration values. This phenomenon seems to have emerged as a consequence of the particular development history of Israeli cities.

Keywords: Street network, urban form, spatial integration, space syntax, Israeli cities

1. Introduction
Street network patterns are a dominant component of a city's spatial form. They have been shown to be significant for human spatial behaviour, including such phenomena as transportation, mobility and accessibility (Batty, 2005; Marshall, 2005), active travel (Frank et al., 2005), human wayfinding and imageability (Golledge and Stimson, 1987; Lynch, 1990) as well as affecting the safety and vitality of urban life (Jacobs J., 1961; Jacobs A., 1993; Southworth and Ben Joseph, 1996; Wheeler, 2008).
Urban street networks have been investigated with respect to their geometric and formal properties, their dynamics and their relationship to other morphological components such as buildings, plots, lots and suchlike. One distinctive approach applied to the investigation of urban street networks is the configurational approach, which focuses on the integration between urban streets (or places) and their relative accessibility (Batty, 2009; Kropf, 2009). These configurational aspects, investigated primarily by means of topology-based methodologies, have been used to compare different street patterns (Hillier, 2002; Marshall, 2005), to distinguish between different modes of street pattern development, i.e., self-organised versus planned-cities (Porta et al., 2006; Jiang, 2007) and to understand the role of human movement in shaping urban street networks (Hillier et. al, 1993).

Space syntax, one of several methodologies belonging to the configurational approach, is currently the dominant theoretical and methodological framework applied when investigating urban form (Hillier and Hanson, 1984; Hillier, 1996). Space syntax theory assumes that urban form is a product of spatial culture (Hillier and Hanson, 1984); in consequence, numerous street patterns from different parts of the world have been investigated within its framework (Read, 1999; Asami, et al., 2001; Hillier, 2002; Crucitti et al., 2006; Porta et al., 2006). This body of research has produced culturally-grounded classifications of these patterns according to their spatial integration characteristics.

The research reported here deals with the spatial configuration of a sample of typical Israeli cities, looked at in terms of their street networks, paying special attention to their patterns of spatial integration. The majority of contemporary Israeli cities emerged during an intensive period of settlement, beginning in the late 19th century and continuing up to the present. Previous studies have classified these cities into several types according to the periods at which they were established, their different socio-geographic contexts and the planning approaches that were employed to guide and constrain their development (Efrat, 1984). In this research, city types have also been distinguished by two further aspects of urban form that potentially affect spatial integration, namely the spatial structure of their built-up areas and their typical street patterns. These were examined with respect to differences in the cities’ topographical conditions and modes of growth. To this end, an empirical study was conducted on a sample of twenty-four representative Israeli cities, which included applying the configrational approach of space syntax.

In the next section of the paper the methodology used in this research will be described; the third section provides background details on the development of Israeli cities, their street patterns and spatial structures. This is followed by a presentation of the research findings regarding the spatial configuration and integration characteristics of the sample of Israeli cities, which will then by compared to findings from similar studies conducted in other cities throughout the world.
2. Measures and methods for analysing a city's spatial integration

When using the space syntax methodology, the description and identification of a city's spatial form are often (but not invariably) derived from a topological analysis of an 'axial map'. An axial map is defined as the set of longest straight lines of direct visibility and movement that pass through all of a city's streets and open spaces, thereby connecting them into a continuous network. Technically, a topological analysis of an axial map treats the individual axial lines as nodes and all axial line intersections as edges of a connectivity graph. The resulting graph forms the basis for measuring spatial integration.

The measurement of spatial integration on the basis of individual axial lines is normally accomplished by first order measures that include Connectivity, Local Integration and Global Integration, and second-order measures such as Intelligibility (Hillier and Hanson, 1984). For any particular axial line, Connectivity denotes the number of directly linked axial lines. Global Integration indicates the closeness of an axial line to all other axial lines in the system by computing the shortest distance (or step depth) of the respective line from every axial line in the entire urban area. The measure allows well-integrated, accessible streets reliably to be distinguished from segregated, more inaccessible streets, and the mean or average global integration value provides a rough and ready guide to the overall accessibility of the entire settlement. Local Integration computes integration only up to a defined radius of topological distance, which is usually 3, i.e., it measures integration up to 2 axial steps away in every direction from each line under consideration.

Intelligibility is a second-order measure that describes the correlation coefficient (R²) between the Connectivity and Global Integration values for the set of axial lines comprising a given axial map. High Intelligibility indicates a strong correspondence between the distributions of Connectivity and Global Integration values. This means that the degree of connection between individual spaces - the urban space that can be seen and experienced synchronically - provides a good guide to the integration of that space into the system as a whole at the global level (the urban space that cannot be directly seen and experienced). An intelligible system is one in which well-connected spaces also tend to be well-integrated spaces (Hillier, 1996, pp. 93-94).

Previous studies based on these measures and conducted in different spatial cultures (Hillier and Hanson, 1984; Hillier, 2002) have shown that the spatial integration values so obtained have the potential to classify local street patterns as well as to give a rigorous description of the overall configuration of settlement form. For example, these measures were found to be sufficiently powerful to distinguish the Turkish traditional street network from others (Asami et al., 2001) and to characterise the types of different street patterns found in a sample of Dutch cities (Read, 1999).

However, spatial integration is affected not only by the overall form of a settlement's street system and the variety of local street pattern types that it exhibits, but also by the partitions found within the street network. Hillier (1996, 1999, 2002) has suggested a general theory of partitioning to
explain the effect produced by partitions (objects such as buildings, blocks, or open spaces) on the spatial configuration and integration of a given spatial form. The theory includes four basic laws or principles to explain the formation of spatial integration during a settlement's growth: centrality, compactness, contiguity and extension. The principle of centrality states that a partition placed in the middle of a spatial system will create more gain in depth than one placed at the perimeter. Extension predicts that adding a longer partition will add more depth to the system than a shorter one, and similarly adding a single, contiguous partition of a given length will add more depth than several shorter, non-contiguous partitions that add up to the same length. The compactness principle shows that adding a linear partition creates more depth than adding a compact, L-shaped or U-shaped one of the same length.

Figure 1 illustrates these principles by using selected grids, taken from Hillier (2002, p. 168). Each grid has the same number of metric cells (301 uniform cells); hence, differences between grids are entirely due to the arrangement of the cells into different configurations. Grid A, the standard uniform grid serves as the benchmark. The configurations of the other grids illustrate the effect of the four principles on the mean trip length (from each cell to all others) for each increase or decrease in that distance resulting from a change in the grid.

The principle of centrality proposes that a centrally-placed partition decreases spatial integration more than a peripherally-placed partition. As the difference between grids B and C in Figure 1 illustrates, placing the partition in the centre increases the grid's mean trip length by 2.6%, whereas placing it in the corner reduces it by 0.3%. This occurs because a partition's location within the grid affects the relationship between the long and short lines; when the break is in the pattern's periphery, more lines remain longer relative to the case where the break is in the centre. Compactness suggests that the more compact a partition (i.e., the more its shape approximates a circle), the less the decrease

![Figure 1](image-url)
in spatial integration in the surrounding space. A compact partition (see Grid B) will thus always generate greater integration than will a linear or elongated partition (see Grid K); hence, the mean trip length is smaller. According to the principle of contiguity, contiguously-arranged partitions increase depth more than do discretely arranged partitions (see the difference between grid K and grid L in Figure 1). Finally, Grid G illustrates the principle of extension in that, when more lines are shorter (compared to Grid A) due to its offset internal lines, integration decreases.

It is important to note that, although the preceding description refers to the possibility of movement between cells along metrically shorter paths, the partitioning theory's principles also apply at the urban scale when analysing the effect of introducing blocks and spaces with different shapes and locations, by affecting the topological distances between axial lines (Hillier, 1999). Considering the fact that extended long axial lines are essential for maintaining a city's high level of spatial integration, it becomes clear that blockages located in an area's centre, or arranged in contiguous, linear form (non compactness) or that interrupt the extension of axial lines, will minimize urban spatial integration.

Hillier (2002) has suggested that it is useful to distinguish between centrality and compactness in terms of their potential effects on two aspects of city form. He argues that the centrality principle considers an area's spatial dimensions, specifically, the location of lines, their length and relative location, whereas compactness addresses the area's physical dimensions, such as the size and shape of aggregate built objects (i.e., blocks, open spaces). However, others claim that in addition to partitions, consideration should also be given to the overall urban shape or the geometric shape of the entire street network, which may also affect the integration attributes of street networks (Shpuza, 2007). Similar to the case of space syntax research (Hillier, 1996; Shpuza, 2007), the geometric shape of cities in a geographic context is often characterised through a compactness indicator (Coffey, 1981; MacEachren 1985) that describes the overall form of a given city based on how far that form deviates from a specified standard shape, most commonly a circle, which is the most compact shape.

With respect to compactness, it is important to examine the differences between the metric and visible properties of space. Theoretically, the more linear the shape of a space, the greater is the metric trip length and the lower is the observed integration. The opposite logic holds with respect to movement efficiency. Visual integration increases as lines lengthen, with many cells covered by a single line. Hillier (1996) calls this differential effect of shape on movement and visual integration the 'paradox of visibility' (p. 266). However, as empirical findings have shown (Shpuza, 2007), the spatial integration in real-world cities does not necessarily increase with shape elongation, because the length of axial lines is also affected by irregularities and distortions that characterize some urban grids.
In the study reported here, both the various measures of spatial integration previously described and the spatial principles that predict how spatial integration is affected by partitions and city shape, will be used to investigate the axial maps of the urban street networks of the 24 cities in the sample, in order to characterising the types of cities found in Israel.

3. Street network patterns in Israeli cities

The majority of Israel's cities were established and developed during an intensive period of settlement, starting in the late 19th century and continuing into the present. The process evolved in a context of changing political, cultural and social conditions as well as different planning approaches (Efrat, 1984; Gonen, 1995). This development can be divided into four main stages, each characterised by a dominant city type - old cities, former agricultural settlements (called moshavot) and semi-agricultural suburbs, and two successive waves of new towns, each expressed in their distinctive street network patterns [Figure 2]. The central cities of Tel Aviv, Jerusalem and Haifa all developed throughout these periods and thus incorporate all the street patterns.

Israel's old cities, characteristic of the period prior to 1880, were established centuries before the initiation of Zionist settlement, which began at the end of 19th century; their street patterns were formed mainly during the era of Ottoman rule (1517-1917). Although the street patterns in some cities, e.g., Beer Sheva and Ako (Acre), were planned in a grid form, others exhibited long organic and self-organised development, characterised by unplanned and irregular street patterns [Figure 2.a].

The second stage began with active Zionist settlement in 1880 and ended in 1948, upon the establishment of the State of Israel. Development occurred mainly through the founding of agricultural settlements (moshavot) and semi-agricultural suburbs, especially in the proximity of Tel Aviv (founded in 1909). The street pattern typical of these settlements generally evolved step by step, in an orthogonal manner, as a result of planned linear settlement [Figure 2.b]. Parcels originated as square

![Figure 2. Typical street patterns (an area of 1.5 x 1.5 km.) belonging to different development periods and city types: (a) Old cities; (b) Former agricultural settlements; (c) First wave of new towns; (d) Second wave of new towns.](image-url)
plots, which contributed to the settlements' overall orthogonal or semi-grid pattern (Ben Arzi, 1984). A relatively organised and regular street pattern thus evolved mainly when Palestine was subject to British rule (1917-1948), characterising small settlements together with central cities.

The third stage of urban growth began in 1948, immediately after the declaration of the State's independence, and entailed the appearance of new towns. New towns were established in two main waves. In the first wave (1948-1958), the idea of the garden city was extensively and comprehensively implemented, with low-density, multiple single-storey and low-rise houses, curved T junctions and cul-de-sac streets, as well as the separation of city centres from residential areas, which were designed as "neighbourhood units" [Figure 2.c]. This approach created spatially defined residential neighbourhoods and small-scale community life within the overall urban environment (Brutzkus, 1964; Farhi and Zafrir, 2003). By contrast, the street pattern in the second wave of new town construction (1958-1980) was relatively concentric with high enclosure and low connectivity [Figure 2.d]. This hierarchical street pattern also characterises the ongoing growth of many urban peripheries today (Zafrir-Reuven, 2006). In this respect, it should be noted that, though each city in the sample exhibited the street pattern that was typical when it was established, other more recent street patterns gradually appeared with the passage of time.

These four city types differ with respect to the spatial structure of their built areas. While the spatial expansion of the built area in old cities developed in continuity, building in the *moshavot* was often scattered (Efrat, 1984; Gonen, 1995), with most new neighbourhoods established in the periphery, a trend that resulted in a "spatial gap" between a city's core and its periphery. Two factors can account for the appearance of this spatial gap. First, the public sector's dominance in urban planning at the time made it advantageous to build far from the urban core, where public land was available. Second, autonomous and independent small settlements or neighbourhoods were occasionally incorporated into one municipality. Over time, these spatial gaps were filled with built-up areas. However, this trend differed in its intensity according to the city's geographic location (Gonnen, 1995). By contrast, new towns, especially the second wave of new towns, were established according to a comprehensive development city plan (Brutzkus, 1964), which contributed to the continuity of the built-up area. In addition, city types were distinguished by their topography. While all the *moshavot* cities were located in a plains terrain, sections of the old cities and new towns were located, partly or completely, in a mountainous terrain.

The proposition that the study set out to investigate was that these differences in the city's spatial structure, resulting both from the continuity or otherwise of their built-up areas and their different topographical conditions, may potentially affect spatial integration quite significantly, especially at the global level. In the empirical investigation described below, consideration was therefore given to the spatial structure of city types as well as to their typical street patterns.
4. The empirical investigation

4.1 Research questions and methods

Three research questions were formulated in light of the urban development features described above: What characterises the spatial integration of the sample of representative Israeli cities? To what extent do different city types exhibit common characteristics of spatial integration? How does the spatial partitioning of their street patterns and the overall shape of their street networks affect spatial integration?

The sample of twenty-four Israeli cities selected for analysis represented the full range of street network patterns found in Israeli cities with respect to city type, topography, size and geographic location. The sample included four city types: old traditional cities with an historical Arab core, former agricultural settlements (including former semi-agricultural suburbs), and planned new cities from both the first and second waves.

Axial maps of the selected cities were constructed from these cities' street networks. For this purpose we used Depthmap software (Turner, A., 2004, version 8.15, UCL) for constructing and analysing the axial maps and implementing space syntax measures. A MDS (Multi-Dimensional Scaling) method based on a Euclidian model (computed by SPSS software ver. 16) was used to assist in classifying the cities according their spatial integration values. With this method, similarities between cases or variables (i.e., the cities in our investigation) are represented by Euclidian distances.

In order to measure compactness we used the "circularity ratio" (see e.g., Selkirk, 1982) as follows: $C = \frac{4\pi A}{P^2}$, where $C$ is circularity of the city shape, while $A$ and $P$ denote Area and Perimeter of the city shape, respectively. The measure is constructed by multiplying the ratio area/(perimeter)$^2$ by $4\pi$, with products ranging from '0' (elongated shape) to '1' (perfectly compact shape). City shape is defined as the polygon that includes the entire street network. Area and Perimeter are calculated by converging street network layers into a polygon using MapInfo version 10.0.

4.2. Results

The first step in the investigation involved computing space syntax measures for all the axial maps constructed for the twenty-four cities. Figure 3 presents the similarities and differences between the cities according to their spatial integration (space syntax) values and topological conditions. The second wave new towns are shown to be particularly closely-grouped, whereas the distributions of the first wave new towns and old cities seem to fall into sub-groups based on terrain, and the former agricultural settlements are mainly distributed to the right of the vertical axis. These results indicate that although cities belonging to the same city type have certain similarities, some city types can also be divided into two further categories - integrated and segregated - a result apparently stemming from their topographic conditions and spatial discontinuity, which suggests that a more detailed exploration of the numerical results is required, see below. The cities' spatial integration values according to this enlarged classification are presented in Table 1.
Figure 3. Classification of cities according to spatial integration (space syntax) measures (Local Integration, Global Integration and Intelligibility (R2)) by means of MDS, based on a Euclidian model (S-stress values are less than 0.001). The Euclidian distances between cities on the 2D diagram represent how similar they are with respect to spatial integration values (i.e., if two cities have similar spatial integration values, they will be located in close proximity on the diagram). The cities are identified by city type and location.

<table>
<thead>
<tr>
<th>Comp. Glob Intel.</th>
<th>Glob Int.</th>
<th>Loc Int.</th>
<th>Conn</th>
<th>City Name</th>
<th>City Category</th>
<th>City Type</th>
</tr>
</thead>
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<td>0.177 0.096</td>
<td>0.728</td>
<td>1.766</td>
<td>4.0</td>
<td>Natanya</td>
<td>Less</td>
<td>Former</td>
</tr>
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<td>1.816</td>
<td>3.928</td>
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<td>integrated</td>
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</tr>
<tr>
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<td>0.884</td>
<td>1.983</td>
<td>4.466</td>
<td>Ramat Gan</td>
<td>integrated</td>
<td>settlements</td>
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<tr>
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<td>3.625</td>
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<td></td>
<td></td>
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<tr>
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<td>1.719</td>
<td>3.595</td>
<td>Naharia</td>
<td></td>
<td></td>
</tr>
<tr>
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<td>3.923</td>
<td>Average</td>
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<td>1.776</td>
<td>3.797</td>
<td>Bat Yam</td>
<td>More</td>
<td></td>
</tr>
<tr>
<td>0.469 0.195</td>
<td>1.227</td>
<td>2.048</td>
<td>4.394</td>
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<td>integrated</td>
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<td>4.140</td>
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<td>3.517</td>
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<td>1.708</td>
<td>3.727</td>
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</table>

Table 1. Spatial integration (space syntax measures) and compactness values for the selected Israeli cities by city type and category, arranged according to Global Integration Value and MDS classification [Figure 3]. Key: Comp. - Compactness; Glob Int. - Intelligibility; Glob Int. - global integration; Loc Int. - Local Integration (for a radius of 3); Conn. - Connectivity.
Former agricultural settlements (*moshavot*)

These cities were characterised by relatively high levels of connectivity and local integration due to their nearly perfect orthogonal grid street pattern. However, cities of this type were also assigned to two sub-categories as a result of significant differences at the global level [Table 1].

The category 'less-integrated cities' was characterised by low levels of Global Integration and Intelligibility (0.85 and 0.14, respectively), mainly due to discontinuities in the street network. As the axial map of Hadera [Figure 4a] illustrates, partitions in the street network of these cities tended to be located in the centre as a result of their unique spatial development, with few long axial lines connecting the city’s disparate parts. Furthermore, this category also included cities characterised by low degrees of street network compactness. For instance, the global integration of Ramat Gan is relatively low although it has no partitions; instead, it is characterised by an elongated and warped form that results in shorter lines, which may explain its low global integration values [Figure 4.b].
Such a form also exhibits great differences in the spatial distribution of Local and Global Integration, reflected in low levels of Intelligibility. Thus, the potential of elongated shapes to create long lines and increase integration between lines remained unfulfilled due to discontinuities in the street network and irregularities of form; the compactness level in this group was much lower than that of more integrated cities (0.27 and 0.5, respectively). By contrast, the cases designated 'more-integrated cities', where the Global Integration and Intelligibility levels were much higher (1.28 and 0.31, respectively), exhibited relatively few partitions in their street networks; hence, their main streets sprawled across the city (e.g., Raanana; Figure 4.c). It should be noted that the continuity of the street network can be related to these cities’ geographic locations. In former agricultural settlements like Raanana and Petach Tikva, or semi-agricultural suburbs like Bat Yam, all three of which are located in the inner portions of metropolitan Tel Aviv, urban growth was faster relative to distant cities like Hadera and Natanya.

**Planned new towns - the first wave**

The cities in this group were distinguished mainly by their topography: all the cities located in a mountainous terrain were classified as less-integrated on the basis of the numerical results, whereas cities located in the plains, excluding Dimona, which has a large empty area in its centre, were classified as more-integrated cities. A mountainous terrain created conditions for curved and concentric street patterns as well as for the discontinuity, fragmentation, and lower compactness of its built areas (e.g., Migdal Haemek, Figure 5.a). These effects had significant implications for spatial integration in these cities, especially for Global Integration and Intelligibility, which achieved the, relatively, very low values of 0.75 and 0.15, respectively.

![Distribution of Local and Global Integration values in selected cities, first wave of new towns.](image-url)
The relatively high levels of Global Integration and Intelligibility (an average of 1.10 and 0.28, respectively) among the plains cities, considered more-integrated cities, can be related to their relatively orthogonal street patterns and the continuity of their built areas in addition to a relatively high level of compactness (e.g., Kiryat Gat, Figure 5. b). Like the case of the former moshavot, the compactness level in more-integrated cities was higher than in less-integrated cities (0.58 and 0.4, respectively). However, here the potential of elongated shapes to increase integration was not fulfilled since these shapes, which developed in a mountainous terrain, tended to be irregular.

**Planned new towns - the second wave**

The street networks of the new towns built in the 1960s and later (e.g., Ashdod and Modiin, Figure 6) were relatively more hierarchical and distinguished by neighbourhoods characterised by enclosures as well as many culs-de-sac and T-junctions. As a result, they received very low Local Integration and Connectivity values. In contrast, their Global Integration as well as Intelligibility values tended to range from medium to high, thanks to their comprehensive city plans. These factors resulted in a global spatial structure of long axial lines that covered the city's areas, as illustrated by Ashdod [Figure 6.b].

![Figure 6. Distribution of Local and Global Integration values in selected cities, second wave of new towns.](image-url)
**Old cities**

The more-integrated old cities, Lod, Ramla and Ako (Acre) were located in a plains terrain. Despite their historical Arab cores, their Local and Global Integration values tended to be average relative to other cities. These values were influenced, most likely, by the newly built and planned areas that partly extended into the original Arab core. However, in Ramla and Lod, where the old city cores still served as the current city cores, the values for Intelligibility were interestingly and even surprisingly high. This outcome apparently resulted from the spatial distribution of the main axial lines across each city's area, in that the lines converged in the city's core (e.g., Lod, Figure 7.a). This spatial distribution can be related to the historic development of these cities along the ancient major roads that had connected these former Arab cities with their surrounding settlements. Conversely, the less-integrated cities, Zefat and Tiberias, had developed in terrains of varying topography. As expected, their street networks tended to be interrupted by many partitions, with primarily curved and concentric streets exhibiting relatively low levels of compactness (e.g., Zefat, Figure 7.b). The significant differences in the spatial integration of these two categories of old cities are shown in Table 1.

![Figure 7. Distribution of Local and Global Integration values in selected old cities.](image-url)
The obtained results indicate that cities belonging to the same city type tend to reveal similar spatial integration on the local level, which is affected primarily by street patterns. In contrast, they differ significantly on the global level, which is affected primarily by the discontinuity and shape of the street network, products of the differential growth rates of the built area (in the case of former agricultural settlements) and topographical conditions (in the case of the old cities and the first wave of new towns). Unlike these city types, no significant differences were obtained for cities belonging to the second wave of new towns. These cities exhibited relatively low values for Local Integration, values that significantly distinguished this from other city types.

These results indicate that global integration is significantly affected by the geometric properties of a city's spatial structure. The potential of elongated forms to create long lines and increase integration is frequently remains unrealised due to the fact that elongated shapes are either located in a mountainous terrain and tend to be irregular and curved, or the city's built area is discontinuous and fragmented. In contrast, the potential of compactness to minimize topological distances (like metric distances) between lines continues to apply, as expressed in higher spatial integration; for all city types, city shapes exhibit higher compactness in the more-integrated categories.

A comparison of average spatial integration (syntactic) values for all the cities examined with those of cities in other parts of the world revealed that overall, Israeli cities exhibit spatial integration values similar to those of UK-European cities. However, they are characterised by relatively low Local Integration values. This finding expresses the small gap between Local and Global Integration in Israeli cities. For example, average Local Integration in Israel is 1.70 whereas in European cities exhibiting similar levels of Global Integration, the Local Integration value is 2.25 [Table 2].

<table>
<thead>
<tr>
<th>Cities</th>
<th>Conn</th>
<th>Loc Int.</th>
<th>Glob Int.</th>
<th>Glob Intel.</th>
</tr>
</thead>
<tbody>
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<tr>
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<td>1.619</td>
<td>0.650</td>
</tr>
<tr>
<td>Israel</td>
<td>23</td>
<td>3.727</td>
<td>1.708</td>
<td>0.880</td>
</tr>
</tbody>
</table>

Table 2. Averaged spatial integration values (space syntax measures) for cities in different parts of the world (these values were taken from Hillier, 2002, p. 157) and in Israeli cities. Key: Conn. - connectivity; Loc Int. - local integration (in radius 3); Glob Int. - global integration; Glob Intel. - intelligibility.

5. Conclusions

The spatial integration of the Israeli cities examined here tended, in general, to vary by city types. However, a comparison of cities belonging to the same city type has indicated that while these cities may exhibit similar integration values on the local level, a result apparently stemming from their similar street patterns, they may nonetheless differ at the global level, an outcome that may be attributed to their different kinds of partitions in the street network. This result confirms the proposition stated at the beginning of this paper, that spatial integration at the global level is affected mainly by the continuity and form of the street network and less by the particular street pattern.
These research findings can be linked to two generative processes affecting the development of settlement forms (Hillier and Hanson, 1984; Hillier, 1996, 2002): socio-cultural process that generate differences in local grid patterns and apparently reflect differences in spatial culture, and micro-economic process that generate the global spatial structures contributing to the integration of city areas. Socio-cultural processes, in this case, the similar circumstances of city establishment and development, can be viewed as responsible for the resemblances found between cities belonging to the same type at the local level, whereas micro-economic processes, in their response to functional and geographical variation, can be viewed as responsible for their differences.

The relatively small gaps between the Local and Global Integration values obtained for Israeli cities can be explained by the simultaneous operation of these two processes during the respective cities’ development. On the one hand, their development was characterised by urban planning abiding by the functional criteria of economic efficiency and accessibility, expressed in a global spatial logic that contributed to high Global Integration levels. On the other hand, the manner in which the plans were implemented, the cities’ establishment and development in response to social criteria regarding community and neighbourhood units, was reflected in highly enclosed, concentric and hierarchical street patterns, features that resulted in relatively low spatial integration at the local level.

The findings obtained from this configurational analysis of Israeli cities concisely illustrate how the geometric properties of spatial structure are expressed in their configurational-topological properties. However, further research is needed to link the configurational properties of the Israeli cities included in the current research with their developmental, geographic and topographic features and investigate in-depth the implications that space has for their current patterns of everyday space use.

Further research is also needed to clarify how these differences in spatial configuration affect spatial behaviour in Israeli cities. In the near future the authors intend to do so by examining the impact of configurational aspects of a city’s spatial structure on social residential patterns, residential neighbourhoods and pedestrian movement. The cities to be examined will be selected from among those belonging to the current sample.

6. Notes
1 The British governed Palestine and ruled the area under a Mandate from 1917 until 1948. The core of Tel Aviv was built entirely according to the Geddes plan, formulated in 1925 according to a Garden City model. This model was also implemented in several neighbourhoods in Jerusalem and Haifa, especially during the 1920s and 1930s.

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References


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