A GIS framework for evaluating the effect of social homogeneity on perceived neighborhoods

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INTRODUCTION

Social and physical properties of urban environments are considered integral components of perceived neighbourhoods i.e. subjectively defined neighborhood territories (Lee, 1968; Pacione, 1983; Brower, 1996). However, while the influence of the environment's physical properties has been examined empirically (Rapoport, 1982; Skjaeveland and Garling, 1997), no studies of perceived neighborhood provide empirical evidence, based on objective spatially-referenced social data, for the influence of the environment's social properties. The reason for this is probably not ideological, but technical: Objective social data are mostly available in aggregated areas, such as official political units, and therefore are insufficient for the examination of fine-scale perceived neighbourhood territories, whose size is mostly much below the average size of aggregated official areas, and which often do not fit into their borders.

The dichotomy between objective aggregate data and subjective individual data can also be observed in the way existing socio-economic geographic information system (GIS) data sets are constructed and maintained. Governments and municipalities provide GIS maps and databases according to census partition units, which makes such data useless for intensive idiosyncratic geographical study (Talen, 1999). For this reason, a GIS has recently been constructed to handle subjective data. Recent studies show the potential of GIS as a powerful tool to analyze the relations between the territory people perceive as neighborhood and their experience and familiarity space (Aitken and Prosser, 1990; Aitken et al. 1993; Schnell et. al., 2005). However, to date, fine-scale GIS applications in perceived neighbourhood studies are limited mainly to subjective data only. In a case where the social properties of the environment were taken into consideration, they were considered by aggregate social properties (Ceccato and Snickars, 2000).

The aim of this paper is to propose a GIS framework based on several sources: a detailed geo-referenced socio-demographic census data; detailed infrastructure GIS maps; and subjective data on perceived neighborhoods. Such data can enable the combining, on the same level within a GIS framework, of subjective data concerning perceived neighbourhoods' territories and objective house-level social census data. This possibility enables to analyze the relations between two fundamental types of geographic regions: cognitive region and socio-economic/administrative region (Montello, 2003). In this paper we concentrate on the effect of social homogeneity on the territory of the perceived neighbourhood. More specifically, our intention is to examine how social homogeneity among residential distribution effects the location of perceived neighborhood's territory which is considered in the literature as an integral component of neighbourhood social constitution (Pacione 1983; Ceccato and Snickars, 2000). The combination of detailed objective and subjective geo-referenced data are appropriate for this aim. The framework is illustrated by a study of perceived neighborhoods' teritories in Tel Aviv.

In the following section, I discuss the concepts of social homogeneity and perceived neighborhood. In the third and fourth sections, I present the methodology and the findings on Tel Aviv residents' perceived neighborhoods. Implications of the suggested GIS framework are discussed in the concluding section.

CONCEPTS

The discussion on perceived neighborhoods is concerned mainly with the aspects that are involved in shaping them and the way they are connected. In his well-known typology of neighborhood schemata, Lee (1968) differentiates between three aspects responsible for an individual's perceived neighborhood: social interaction (social acquaintance); functional space (unit neighbourhood); and social homogeneity (homogenous neighborhood). By that typology, Lee distinguishes between personal experience, on one hand, and the socio-physical properties of their surrounding environment.

Even though, the physical and population's socio-cultural properties are involved eminently in the process of neighboring (Brower, 1996), they can be distinguished heuristically. The physical (built-up) environment properties such as land use, street pattern, house type, and identifiable boundaries play a main role in the identification of neighborhood (Golledge and Stimson, 1987), however, they do not have necessarily determinate effect on social relations; their effect is highly dependent on the prior conditions of social homogeneity or similarity. As Abu-Ghazzeh argued, "People prefer to associate with like-minded others. No amount of physical closeness will overcome the social distance." (1999, p.43). Moreover, social homogeneity or social similarity themselves affect neighboring independent of social interactions and cohesion. In addition, social homogeneity also allow integration between other dimensions involved in this process of neighboring such as social relations, cultural and ideological values, and perceived territory (Brower, 1996; Valera and Guardia, 2002).

The degree of overlap between perceived neighborhood territories was chosen in the study as an indicator for evaluating the coherence of residents' perceived neighborhoods in a given municipal neighborhood. This decision is based on the assumption that the agreement between people on the delineation of the neighborhood's boundaries is appropriate indication of an integrative neighborhood, in the sense of neighboring (Altman and Low, 1992) and neighborhood social constitution (Schnell et. al., 2005).

METHODOLOGY

The methodological issues concerning the evaluation of the effect of social homogeneity on the delineation of neighborhoods' boundaries include the data sources and the measurement of overlap between delineated territories and the socio-spatial homogeneity in residential distribution.

The Data

The subjective data on the delineation of perceived neighborhoods' boundaries for the current study come from a survey of 533 telephone interviews in 22 administrative municipal neighborhoods of Tel Aviv city, chosen to represent the socio-spatial distribution of the city, and a random sample within each of them[1]. However, the data includes the neighborhood delineation of 351 respondents who were able to specify coherently the boundaries of their neighborhoods.

For locating the territorial boundaries of perceived neighborhoods, the respondents' delineations were drawn on a MapInfo Professional 8 program as polygons. To calculate the average degree of overlap between these territories we calculated the overlap between each pair of those polygons. The calculation is as follows:

$$P_k = \Sigma pi \; \Sigma pj \; [(Pi \,/\, Pj)*100]/N \qquad (1)$$

[1] The survey included various questions concerning the residents' social properties (for details see: Schnell et. al., 2005). However, the current research purposes use the neighborhood delineation only; the interviewees mentioned the name of the streets that delimit their neighborhood' boundaries.

Where P_k is the overall average degree of polygons overlapping in a given area (municipal neighborhood or a certain defined group of polygons) k, p_i and p_j represent all pairs of polygons and N denotes the number of polygon pairs in a neighborhood.

The objective social data study is based on detailed geo-referenced household data of the Israeli Census of Population and Housing for 1995, In this GIS framework, household records are linked to the polygon representing the house, and, thus, enable the analysis of spatial relationships between individuals' perceived neighborhood and the physical and social properties of those neighborhoods. The study is concentrates on the distribution of the income level, which found appropriate to represent the socio-economic status of the Israeli city's population (Omer, 2006).

Measuring fine-scale social residential distribution

Many segregation indices are used for the description of overall urban social residential distribution. Mostly, they are limited to aggregate areas and therefore do not take into account variation and spatial relations between individuals located within the area - all of which makes their usage problematic for measuring high-resolution residential segregation of the kind used in this study (Benenson and Omer, 2002).

The alternative local approach describes residential distributions by means of *local indices of spatial association* (Anselin, 1995). These indices are based on the comparison of the characteristics of a given spatially located object and its neighbors. In our case, the census GIS makes it possible to compare the characteristics of the residents in a given house with the characteristics of the householders living in other houses within that house's neighborhood. Because the aim of measuring in this paper is to describe the degree of social heterogeneity/homogeneity within a defined neighborhood, the Geary index K_i, can be appropriate. Geary index K_i estimates the local variance of social property *f* as follows:

$$K_i = \Sigma_{j\in U(i)} w_{ij}|f_j - f_i|/(W_i s) \qquad (2)$$

where f_i denotes the value of social property f at house i, U(i) denotes the neighborhood of i, <f> is an average, and s^2 is the variance of f over the entire area. The set of non-negative weights w_{ij} (where $w_{ii} \equiv 0$ for each i) defines the a priori "influence" of neighboring locations on location i, where $W_i = \Sigma_{j\in U(i)} w_{ij}$. K_i is always positive, and its value represents the heterogeneity of the neighborhood U(i) of i. In this paper, neighborhood U(i) is defined by the adjacent houses of i.

The definition of neighborhood, U(i), in this paper, is based on coverage of Voronoi polygons. Two houses are considered adjacent if their Voronoi polygons have a common edge. For that purpose we use the MapInfo™ 8 GIS, Vertical Mapper and MapBasic application working within a MapInfo environment for constructing Voronoi coverage, determining polygon adjacency, and constructing the set of neighbors for each house. After the neighborhoods of all houses are defined, the Geary index can be calculated for all houses in the area. Geary index also applies for measuring the outer variance of a given area. In this case, <f> represents the average of the entire area and U(i) represents the adjacent areas.

RESULTS

The first action for evaluating the effect of social homogeneity on the territorial boundaries of perceived neighbourhoods was to identify their boundaries. The results of this examination clarify that most of the perceived neighborhoods' territories do not fit the municipal neighborhoods' territory; the average overlap degree between the perceived neighborhood and the municipal neighborhood is 34% only. Likewise, as illustrated in figure 1a, there is low agreement between the perceived neighborhoods' territories themselves when they examined at level of municipal neighborhoods; the average degree of overlap between the perceived territories in all municipal neighborhoods is 38%.

To locate formally aggregate perceived neighborhoods (agreement on the territory that perceived as neighborhood by the residents) the following categorized formula was used in each municipal neighborhood: In the first stage, we categorized the respondents' polygons (each polygon represents perceived territory) that share more than 75% overlap territory into groups of polygons (P_k>75%). The aggregate perceived neighborhoods that were created in this procedure are presented in figure 1b. Detailed examination of these perceived boundaries reveal that in 17 out of 22 municipal neighborhoods there are distinct aggregate perceived neighborhoods.

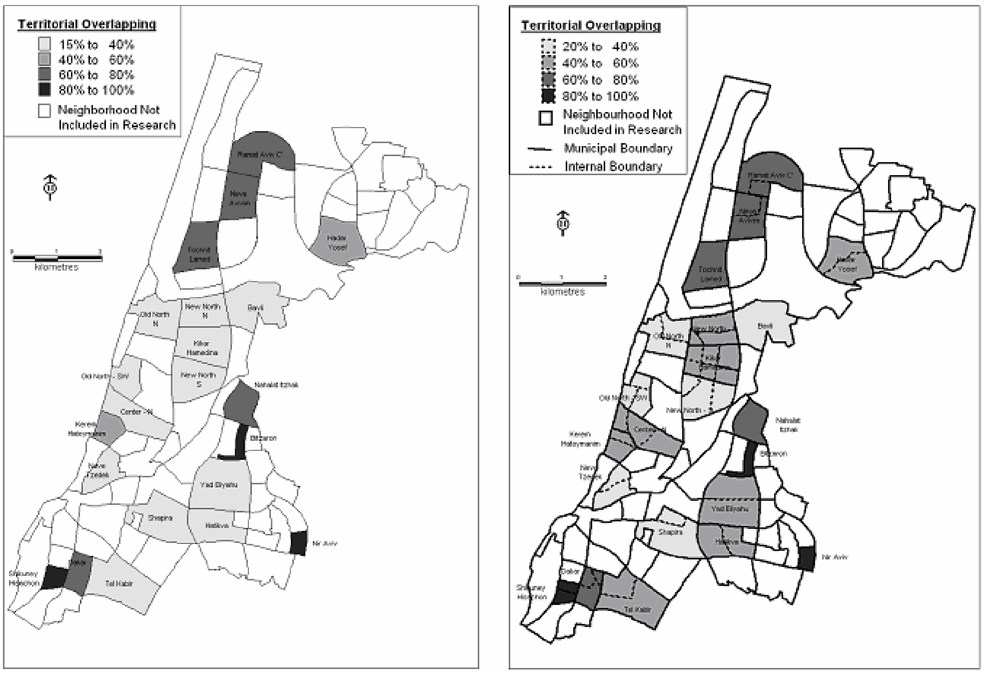

Figure 1: The degree of territorial overlap between perceived neighborhoods within (a; left) municipal neighborhoods (b; right) the area constructed according the perceived boundaries

In order to evaluate how the geographical distribution of income affects the delineation of neighborhood territory, a correlation was measured between the degree of neighborhood territory overlap and the income heterogeneity measured by Geary K1 at the building level in each of the aggregate perceived neighborhood as shown in figure 1b: The results of this examination (figure 2) show a significant correlation R= - 0.43 (p~0.03). This finding means that the agreement on the neighborhood's territory is influenced by the income level, or maybe other related factor like the education level. Based on this finding, we can conclude that generally, a socio-spatial homogeneity encourages agreement between residents on common territory. Specifically, as it can be shown in figure 2, almost all the municipal neighborhoods with a high degree of overlap have a low socio-spatial heterogeneity. However, the reverse does not apply: there are neighborhoods with low K1 value that have low degree of overlap. That is, social homogeneity is a necessary condition for creating agreement on neighborhood territory but could not determine such agreement in a sense of sufficient condition.

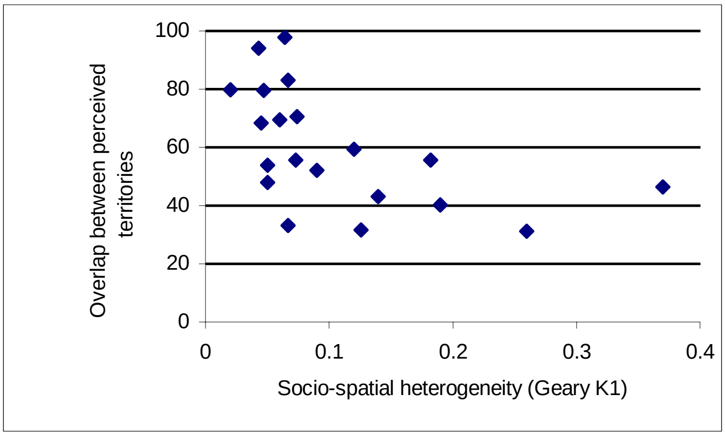

***Figure 2*:** The correlation between degree of overlap and income spatial heterogeneity measured by Local Geary at house level over municipal neighborhoods if Tel Aviv

Another examination concentrates on the influence of the income distribution on the location of the aggregate perceived neighborhoods' boundaries (figure 1.b). For that purpose we used the T-test procedure, where there is one perceived boundary within a municipal neighborhood, and the Anova procedure in the case of more than one perceived boundary. These procedures check if the perceived aggregate boundary passes between different income groups. The T-test procedure applies also to the municipal boundary of the five undivided municipal neighborhoods where the perceived boundary fit the municipal boundary. The results of these tests are presented in figure 3. The results show that in 25 out of the 48 aggregate perceived neighborhoods the boundaries pass between significantly different income groups ($p< 0.05$). These neighborhoods signed in figure 3 as "significant subdivision"; against that, "not significant subdivision" means no correlation with the income distribution. Thus, in approximately half of the perceived neighborhood the boundaries fit the boundaries between populations that have different income levels. Examination of the spatial pattern of these neighborhoods creates an interesting picture: all these municipal neighborhoods are located in the northern and eastern areas of the city. In contrast, the perceived boundaries in the central and southern areas of the city do not correlate with the income spatial distribution.

At this stage, we can consider the spatial division revealed in Tel Aviv. For this purpose, the correlation between social homogeneity and degree of overlap was computed regarding the northern and eastern neighborhoods only. As expected, the correlation between the overlap and the level of spatial heterogeneity grew from $R= - 0.43$ ($p\sim0.03$) to $R=- 0.544$ ($p< 0.01$). Furthermore, the outer spatial heterogeneity of those areas (the variance between a given area and the adjacent areas measured by Local Geary) also correlates to the degree of overlap in a given area in these parts of the city $R= - 0.31$ ($p\sim0.08$). When we take into account the internal spatial heterogeneity and the outer spatial heterogeneity simultaneously by multiple regression, the correlation between territorial degree of overlap and the socio-spatial residential distribution become slightly stronger: $R= - 0.563$ ($p<0.02$).

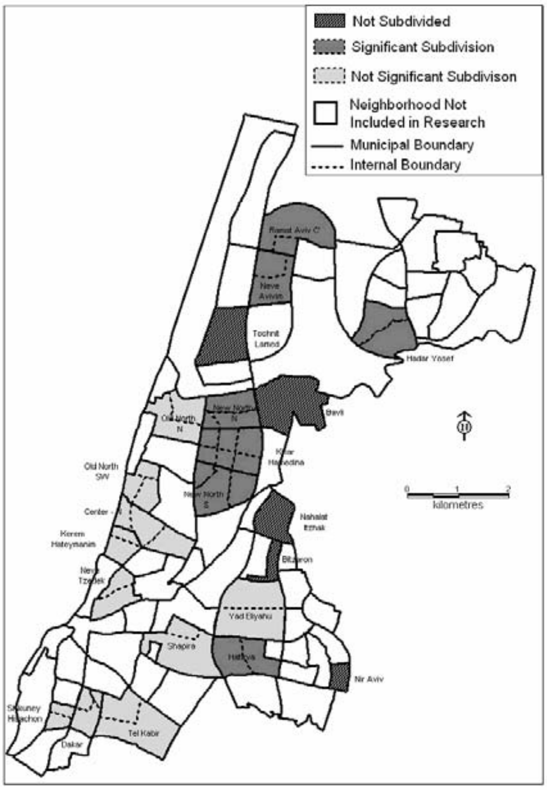

Figure 3: Categorization of municipal neighborhoods according to the significant value of T-test/ Anova regarding income variance between subareas within municipal neighborhoods.

This leads us to conclude that the effect of social homogeneity on construction of common perceived territory depends on geographical context, which probably includes other factors in addition to income spatial distribution. These northern and eastern parts of the city are relatively new parts of Tel Aviv that were developed as neighborhood units mainly after the establishment of the State of Israel in 1948. The main character of these areas - the socio-demographic profile of the population- goes some way to explain this phenomenon. Residents of a relatively high socio-economic status and a high percentage of people of Western ethnic origin characterize these areas, while the southern and central areas are characterized by low-income earners and a population of Eastern origin.

Hence, we can summarize that even if the effect of socio-spatial homogeneity depends on geographical context, it has the potential to provide a setting for agreement between residents on their perceived neighborhood territory. The outcome of that potential could be a contribution to similarity between municipal neighborhoods and perceived neighborhoods, on one hand, and subdivision of municipal neighborhoods into subareas perceived by residents as the real neighborhoods, on the other.

CONCLUSIONS

The main conclusion of this study is that the degree of residential socio-spatial homogeneity does indeed influence the residents' perceived neighborhood territory. More specifically, the degree of overlap between perceived neighborhood territories tends to correlates with the level of socio-spatial homogeneity in the territory covered by them. Moreover, social homogeneity is revealed as a necessary condition, but not sufficient condition, for creating agreement on neighborhood territory expressed by high degree of overlap.

The results of the current study could have operative implications for planning, especially the need to consider the socio-spatial homogeneity when delimiting municipal neighborhoods in urban space. This is important specifically where the municipal neighborhood's boundaries, as raised in current study, do not fit the territories perceived by residents as neighborhoods.

Broadly speaking, detailed GIS social census data, by making possible the combination of objective and subjective data, such as residents' socio-economic characteristics, on one hand, and their perceived neighborhood, on the other, contribute to combine idiosyncratic and objective perspective in the study of neighborhoods.

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