The Prospects and Problems of Integrating Sketch Maps with Geographic Information Systems (GIS) to Understand Environmental Perception: A Case Study of Mapping Youth Fear in Los Angeles Gang Neighborhoods

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ABSTRACT

How people feel about places matters, especially in their neighborhood. It matters for their health, it matters for the health of their children, and it matters for their social cohesion and use of local resources. A growing body of research in public health, planning, psychology, and sociology bears out this point. Recently, a new methodological tack has been taken to find out how people feel about places. The sketch map, a once popular tool of behavioral geographers and environmental psychologists to understand how people perceive the structural aspects of places, is now being used in concert with Geographic Information Systems (GIS) to capture and spatially analyze the emotional side of urban environmental perception. This confluence is generating exciting prospects for what we can learn about characteristics of the urban environment that elicit emotion. However, due to the uncritical way this approach has been employed to date, excitement about the prospects must be tempered by the acknowledgement of its potential problems. This paper reviews the extant research on integrating sketch maps with GIS and then employs a case study of mapping youth fear in Los Angeles gang neighborhoods to demonstrate these prospects and the problems, particularly in the areas of 1) representation of environmental perception in GIS and 2) spatial analysis of these data.

Keywords: sketch maps, Geographic Information Systems (GIS), environmental perception, fear

BACKGROUND

Numerous studies have indicated that people's perception of certain characteristics in the urban environment influences a range of behaviors, from engaging in physical activity to socializing with neighbors; these behaviors then have implications for their mental and physical health, as well as for the vitality of the neighborhood (White, et al., 1987, Ross, 1993; Loukaitou-Sideris, 2006; Gomez et al., 2004; Stafford, Chandola, Marmot, 2007; Roman, Chalfin, 2008). In the past two decades, a growing number of these studies have incorporated geographic information systems (GIS) in their methodological toolkit for examining this relationship. In particular, GIS has been used to map characteristics of neighborhood environments that are hypothesized to have negative impacts on health outcomes and other measures of well-being. These characteristics range from coarse scale aggregations of census data on vacancy to fine-scale neighborhood surveys that capture individual features such as broken windows, trash, and alcohol advertisements. However, a recent call has been made to move from a focus on purely observable features of urban neighborhoods to how these observable features make people feel (Mason et al., 2009; Mennis and Mason, 2011). It is within this broader vein of research that the current study is situated, and specifically in the methods used to understand the spatial relationships between place and perception in an urban environment context.

Project Overview. In 2007, researchers affiliated with the Social Identity Project (SIP)[1] surveyed male youth in three Los Angeles neighborhoods. One component of SIP involves examining fear in relation to the neighborhood environment. The survey asked a number of questions regarding

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the respondent's perceptions of his neighborhood and community, in addition to other issues. Each respondent drew what he considered to be his neighborhood boundary on a pre-printed street map created from Google Maps. Then, each participant was asked to mark places where he felt afraid with an *X*. Based on observation of the resulting sketch maps, two methodological questions emerged: 1) how to represent these spaces of emotion in a GIS and 2) what spatial analyses are appropriate for understanding these data? In order to answer these questions, it is important to ground the inquiry in the extant research, and particularly in the methodological precedents provided by work in mapping environmental perception, the more recent focus on qualitative GIS, and those studies that explicitly integrate the sketch map with GIS.

Mapping Environmental Perception. Studies of environmental perception have had notable contributions in cognitive mapping[2] from urban designers and planners such as Lynch (1960) and geographers such as Gould and White (1974) and Golledge (1977). These studies focus on the ways people come to know their environments, urban (Downs and Stea, 1973; Lynch, 1960) and natural (Kaplan and Kaplan, 1995). The majority of research in this area is concerned with process, such as how humans orient themselves in a place and how this orientation is affected by variables such as age (Siegel and Schadler, 1977), familiarity (Acredolo et al., 1975), gender (Matthews, 1987), class (Goodchild, 1974), and physical setting (Evans, 1980).

A commonly employed tool for accessing an individual's environmental perception is the sketch map[3]. They have typically been used to examine participants' perceptions of the structural

[2]In his discussion on the terms *cognitive map* and *cognitive mapping*, Kitchin (1994) argues that though many definitions exist due to the multi-disciplinary nature of the subject, in geography, these constructs gained attention through the 1960s behavioral approaches as a response to the positivist turn in the discipline (5). The cognitive map is "a mental construct (be it explicit, analogical, metaphorical, or hypothetical) that actually influences behavior," (Kitchin 1994: 6) and therefore it is one way to understand a person's perception of his/ her environment and subsequent behavior in that environment.

aspects of the physical environment (e.g., accuracy and complexity of recreating cities or neighborhoods) (Appleyard, 1970; Evans, 1980; Evans, Morrero, and Butler, 1981; Kim and Penn, 2004) rather than the emotions attached to place. Kitchin (1996b) describes five types of sketch map techniques: basic, minimally defined, normal, cued, and longitudinal. Though it can be employed as a freeform construct, it can also be presented as a base map upon which participants are instructed to identify places that have certain meaning to them, such as "neighborhood" or "unsafe". Wood and Beck (1989) diverged from the dominant focus on structure and process to conduct work on emotive qualities of cognitive maps using *Environmental A*, a mapping language they developed for this purpose. Unfortunately, that vein of research that is most relevant and promising to the current study never developed beyond a germinal stage.

Though sketch maps have been a commonly used tool for accessing peoples' environmental perceptions, they are not without limitations. For example, Pocock (1976), Evans (1980), and Blades (1990) have all found that variables such as individual characteristics, and instructions and materials may influence the resulting map. In addition, these representations are temporally dynamic based on events and interactions with the environment (Mathews 1980; Kitchin1994) and as such may be based on structural or social features or on past events. Despite these limitations, as well as the time- and cost-intensive nature of the process of data collection, sketch mapping is an established method in accessing people's environmental perception.

Integrating Sketch Maps with GIS. Technological advances, such as computer cartography and then GIS, have brought a renewed interest in the use of sketch maps as a means to capture environmental perception (Kitchin 1996a). Specifically, with advances in heads-up (onscreen) digitizing and spatial analysis capabilities within GIS, integrating the sketch maps in this environment is more fluid than at any time before. This ability enables the inclusion and visualization of multiple environmental perceptions of one area, such as a neighborhood.

Though the technical capabilities for sketch maps to be integrated with GIS have existed for some time, as noted by Kitchin (1996a, 1996b), an epistemological shift was necessary as well. Indeed, that sketch maps are being used to ascertain the way people feel about characteristics of their environment and that these maps are being integrated in GIS is due, in large part, to the intellectual groundwork that has been laid by scholars in Public Participatory GIS (PPGIS) (Craig, Harris, and Weiner, 2002; Elwood, 2006) and, more recently, in qualitative GIS (Elwood and Cope, 2009). While earlier scholarship from Talen (1999) and Kwan (2002) identifies many of the ways that GIS could be inclusive of qualitative data, subsequent work has focused on advancing practical applications that integrate qualitative data and GIS. For example, Pavlovskaya (2002, 2004) uses in-depth interviews with participants to inform categorization of GIS data on urban change. Mathews and colleagues (2005) introduce the practice of geo-ethnography, while Knigge and Cope (2006) offer a grounded visualization approach for incorporating GIS and ethnography. Kwan and Ding (2008) then outline the geonarrative. Hawthore, Krygier and Kwan (2008) use photo-based Q methods, and Jung (2009) and Jung and Elwood (2010) propose computer-aided qualitative GIS (CAQ-GIS) software. From these substantive and methodological contributions, the meaningful integration of qualitative data with GIS has been demonstrated to be possible and to offer new ways of knowing. It is within this moment that scholars are looking to a variety of existing qualitative methods to see how and where they can work with GIS for more robust explanations and understandings. As a result, the sketch map as a tool to access environmental perception is experiencing resurgence.

Integrating Sketch Maps with GIS: The Current State of Research. Prior to the advent of GIS, a number of researchers employed the sketch map to ascertain the boundary of neighborhoods and perceptions of places (Lee 1968; Ladd 1970; Maurer and Baxter 1972; Haney and Knowles 1978; Karan et al. 1980; Mathews 1980). More recently, though the sketch map is commonly utilized to define structural perceptions of place, such as neighborhood boundaries (Coulton et al. 2001; Spilsbury, Corbin, and Coulton 2009), as well as ascertaining the affective quality of places; these data are then being mapped and analyzed in a GIS (Ratcliffe and McCullagh 2001; Matei, Ball-Rokeach and Qui 2001; Doran and Lees 2005; Dennis 2006; Kohm 2009; Lopez and Lukinbeal 2010). Of the twelve studies that have integrated sketch maps with GIS, outlined in Table 1, half of them focused to some degree on residents' fear of certain places, though this was articulated using different terms such as safe/unsafe, avoidance, fear, comfort, or concern. The remainder of the studies was interested in activity or boundaries. Therefore, the predominant emotion being mapped and analyzed is fear. Fear mapping is undergirded by a voluminous literature and the specific issues related to approaching fear mapping through the integration of sketch maps with GIS has been addressed in detail elsewhere (Curtis 2012). As a result, though this paper uses a case study of fear mapping, its focus is on the broader methodological concerns of data representation and spatial analysis that are applicable to any environmental perception study that uses the sketch map-GIS approach.

CASE STUDY: MAPPING YOUTH FEAR IN LOS ANGELES GANG NEIGHBORHOODS

Data and Methods. This analysis utilizes a portion of the data collected for the Social Identity Project (SIP). While the SIP addresses a broad range of research questions, one particular piece involves examining fear in relation to the neighborhood environment. The participants in this study include gang members, non-gang members, and former gang members. It is reasonable to expect that these different associations will lead to different areas of fear, or perhaps no fear at all. However, before these relationships with gang affiliation can be analyzed, more basic methodological questions need to be answered: 1) using a sketch map, how should environmental perception be represented in GIS and 2) what are appropriate spatial analyses of these data?

In 2007, SIP researchers surveyed 214 male youth from 14 to 21 years old in three Los Angeles neighborhoods. Local graduate and undergraduate students were employed to recruit and interview youth who had been living or hanging out regularly in the neighborhoods over the prior two years or more. The researchers initially went door-to-door in each area to recruit participants and publicize the study. Over the following four months, recruitment efforts continued by engaging youth congregating outdoors in the designated areas. Informed consent was administered to interested youth and a parent (for youth less than 18 years old) and an hour long interview was conducted in a private location. This resulted in a sample of neighborhood youth that was skewed toward those in street-oriented groups such as street gangs and other types of crews or peer groups. The survey asked a number of questions regarding the respondent's perceptions of his neighborhood and community, in addition to other issues. Each respondent drew what he considered to be his neighborhood boundary on a pre-printed street map created from Google Maps that represented an area larger than the study area from which respondents were selected. The base maps included only major land parcels and streets within the community under investigation. They contained only street names for orientation and excluded institutions and other landmarks to reduce influence on responses. Each participant was asked to mark places where he felt afraid with an *X*. Specifically, respondents were asked: "Are there any particular places in your neighborhood where you or one of your friends are sometimes afraid to go? If yes, please show me where these places are on the map. Mark these places with an *X*." For this study area, of the 81 respondents to the survey, 73% indicated spaces of fear on the map. Based on observation of the resulting maps, the research team discovered that despite the instruction to mark fear spaces with an "*X*", the resulting data differed in four ways: a) small individual *X*s, b) many small *X*s in linear patterns, c) few large individual *X*s, and d) few large individual *X*s with circles drawn around them. Figure 1 provides an example of participant representations of places where they feel fear. Based on these sketch maps, the question emerged of how to represent the data for mapping and analysis in a GIS? This paper addresses this question using one of the three study areas of the project.

As only some of the data demonstrated a linear pattern, but all markings could be digitized as points or polygons, depending on interpretation of the *X*, places of fear were digitized as both point and polygon shapefiles. Creating a polygon shapefile captured the possibility that participants' perceptions of fear lie within a larger spatial area denoted by the extent of the arms of each *X* while the point shapefile captured the possibility that perceptions of fear might be more localized (Figure 2). To create the fear point shapefile, points were digitized at the center of each hand drawn *X*. To create the polygon shapefile, the four endpoints of the *X* drawn by respondents were connected to depict the unique nature of each *X*, which varied in shape and size. When circles were drawn, they were also digitized as polygons.

Analysis. Analytical techniques were selected based on two rationale: because of their precedent of use in existing research that integrates environmental perception data from sketch maps into GIS or their potential of use to understand spatial patterns in participants' environmental perception. Based on these parameters, the following techniques were employed: 1) descriptive statistics of the hand drawn fear spaces, and then in a GIS 2) aggregation to parcels and grid cells, 3) univariate Local Indicators of Spatial Autocorrelation (LISA), 4) kernel density estimation (KDE), and 5) spatial filter. Following the work of Ladd (1970) and Spencer and Dixon (1983), describing the hand-drawn fear spaces is useful to understand the ways participants interpreted the directions and to look for spatial patterns that may suggest a meaningful spatial analytic approach. In this case, the data are characterized by number of fear spaces, mean and median size of fear spaces, and pattern of fear spaces. In a GIS, aggregation is used because it is an approach that is available to all models of vector data, therefore it enables comparison between different data representations. It also has precedence as an approach used in prior studies (Coulton et al. 2001; Ratcliffe and McCullagh 2001; Matei, Ball, and Rokeach 2001; Lopez and Lukinbeal 2010). Though aggregation provides a useful visualization of density of agreement in participant's environmental perception, it is not an analytical tool. Therefore, a univariate LISA was applied in order to find statistically significant clusters of such agreement in the aggregated grid cells (Anselin 1995).[4] Finally, kernel density estimation (KDE) and a spatial filter were applied to search for clusters in the point data. Although kernel density may be a more

[4] LISA was performed using a first order, Queen contiguity matrix. This analytical approach was selected due to its widespread use to identify hotspots in aggregated polygon data (Harries, 2006; Lane, Sui, 2010; Ratcliffe, 2010).

popular approach for identifying clusters in point data, it lacks statistical rigor, which a spatial filter technique provides (Curtis, Duval-Diop, Novak, 2010).

First, drawing on the work of Lopez and Lukinbeal (2010), data were aggregated to parcels[5]. Note that the maps of parcel aggregation have been transformed into thiessen polygons surfaces to protect the location of the study area (Curtis and Leitner 2005). From visual inspection of these data, it became evident that aggregating to parcels did not capture the point interpretation of *X*s marked in roads. An aggregation level was needed that would include the area covered by roads. Therefore, the data were aggregated to 50 meter grid cells. This grid size was selected as it represents approximately one side of a block. Aggregating the sketch map data to grid cells was achieved through the "spatial join" operation, where the GIS selects all objects (fear spaces) that intersect each grid cell[6]. The result is a new column in the attribute table with a frequency count of the number of objects that are located in each grid cell. This technique was applied to both the point interpretation of fear spaces and then polygon interpretation. Once both interpretations had been aggregated to 50m grid cells, GeoDa was used to apply a univariate LISA to the data (GeoDa, v 0.9.5i). This technique is useful for identifying clusters among aggregated spatial units and enables comparison of hot spots based on point or polygon data representation.

Then, turning to only the point representation of fear spaces, kernel density estimation (KDE) and a spatial filter were applied to the point data. KDE is a commonly employed technique for identifying clusters in point data, especially for crime pattern analysis, and

[5]Though Lopez and Lukinbeal (2010) argue that parcels are a meaningful aggregation unit for the spaces in which people act, many of the Xs drawn by participants in this study were along road segments. This spatial pattern would not be well-represented by aggregation to parcels.

[6]Grid cells are not associated with any underlying geography (e.g., roads, buildings, parks) and are therefore preferable as they avoid false spatial designation to land use or socio-economic units.

therefore it was applied to the raw point layer of fear spaces. KDE is a useful technique for visualization, but it is not a statistically rigorous analytical tool per se. Therefore, for the sake of comparison with an explicit spatial statistical technique, a spatial filter was applied. This analysis advances existing approaches from visualization to the calculation of a rate of fear incidence and provides a test of statistical significance. Also, as it is an overlapping filter, the result is a smoothed surface, rather than abrupt aggregations. Any of the grid points can be queried for specific rates at different filter sizes; therefore the perception rate for a particular location (e.g., building, street corner, or location of homicide) could be extracted (Curtis, Duval-Diop, and Novak, 2010).

Each analysis was performed and then the output was compared 1) among aggregation approaches , 2) between point and polygon clusters identified through LISA, and then 3) among aggregation, LISA, and results from hot spot analysis of point data (KDE and spatial filter).

RESULTS

Hand-drawn fear spaces. Of the 81 participants from this study area, 59 marked fear spaces and 22 did not mark fear spaces. Of those who indicated fear, 26 participants drew spaces of fear in a linear pattern which often seemed to align with a road segment. Twelve of the participants drew only a few *X*s (n<6), but on some or all of the *X*s also drew a surrounding circle. Five participants *X*s were scattered. Two participants marked fear spaces in circular or semi-circular patterns. The remaining twelve participants either drew between one and 4 *X*s with no discernible spatial pattern. Table 2 summarizes the number of fear spaces by mean and median size, while Figure 3 provides a graphic representation of the relationship between number and size of these markings. Based on these patterns, some data could be represented as individual points, others as line segments, and others as areas such as parks, blocks, or large sections of the study area. Without participant explanation of why was each X was marked in a particular way, some interpretation is required.

Aggregation of points and polygons: parcels and grids. Figure 4 shows the resulting pattern of aggregation to parcels for a) points and b) polygons. The maps display the number of fear spaces that intersect grid cells as a percentage of all marked fear spaces. Aggregating points results in almost no discernible patterns, while aggregation of polygons produces two hot spots, in a linear pattern in the northern section of the study area and a round area to the southeast. This striking visual difference led to the observation that *X*s drawn in streets were not aggregated to parcels, but were lost from the map altogether. This issue then led to aggregating data to grid cells instead (Figure 5). From this approach, using the point representation leads to one linear area of consensus in the northern part of the study area that is faintly visible. However, aggregating the polygon fear spaces to grid cells results in the identification of two hot spots: a linear segment in the northern portion of the study area and an area to the southeast of that segment. Though these approaches to visualizing the point data representation do not yield consistent results between parcels and grid cells, the polygon representation does look similar, regardless of type of aggregation.

Hot spot analyses: LISA, KDE, and spatial filter. The previous approaches demonstrate meaningful ways to visualize hot spots in different representations of environmental perception. However, they are not spatial analysis procedures. In the interest of moving from visualization to analysis, the following techniques were performed. First, using the point and polygon representations aggregated to grid cells, a univariate LISA was performed on the count of marked fear spaces by grid cell[7]. For the point interpretation, this procedure identifies the same linear segment noted above, but also an area to the southeast (as identified in the polygon aggregation to parcel and grid cell) and an additional segment to the south of and connecting to the first linear hot spot (Figure 6a). For the polygon interpretation, LISA returns a pattern of clusters that are in the same area of those generated for point data, but are more expansive and include the same hot spots identified above in the polygon aggregation to parcel and grid cell.

Representing the data as points, opens the possibility of many more spatial analytical techniques to identify hot spots; kernel density estimation (KDE) is one of the most common (Figure 7a). The results of KDE agree with the point and polygon aggregation of grid cells, and the polygon aggregation to parcels in the identification of the road segment, but this point analysis does not capture the second area of fear to the southeast as identified by the use of polygon data. To increase the analytical rigor, a spatial filter was applied to search for statistically significant hot spots in the point data (Figure 7b). The result of this analysis also shows agreement for the road segment, but does not show the area to the southeast.

In summary, a linear segment has been identified as a hot spot of fear. Both aggregations to grid cells, aggregation of polygons to parcels, both LISA results, KDE, and spatial filter results all agree on this location. The only approach that does not identify the linear segment is point aggregation to parcels. This is to be expected as participant maps show many *X*s in the road between parcels in this area and therefore these markings would not be captured by this approach. In addition, a second hot spot is identified in the area to the southeast of the linear segment. This area results from all approaches using polygon interpretation, as well as from the LISA analysis on the point aggregation to grid cell. The other point-based data and approaches miss this area. Finally, LISA shows more areas of fear than the other approaches; most importantly, the hot spots emerge regardless of data representation.

DISCUSSION

Integrating sketch maps with GIS for visualization and spatial analysis has the potential to illuminate the spatial relationship between perception and place. From planning, policing, and public health perspectives, knowing where youth feel fear in their neighborhoods can be useful for intervention, and improving their outcomes and quality of life. Therefore, the results of this study demonstrate the importance of data representation, and spatial analysis in that, though all methods used in this study yield some consensus of hot spots of fear, some differences emerge as well. However, before highlighting the contributions of this study, its limitations should be addressed.

Limitations. Understanding this study's limitations in design, data collection, and analysis are essential to understanding the bounds of its implications. First, this project draws, in part, on an environmental design framework. As such, places matter and it is believed that places can be designed to elicit certain perceptions (e.g., safe, dangerous). Though fear will certainly vary by person, some places are believed to engender feelings of fear in certain populations[8]. Furthermore, though the Social Identity Project covers several neighborhoods in Los Angeles, this article reports on only one case study focused on the methodological challenges of integrating sketch maps in GIS and the varying results of this approach. Despite having 81 participants from this neighborhood, as with any case study, the possibility exists that results

[8] See Curtis (2012) for a detailed literature review and discussion of spatial aspects of fear and integrating sketch maps with GIS to map fear.

would not be exactly the same as for other participants in other areas. However, as all 214 participants in all neighborhoods followed the same instructions for marking fear spaces with "*X*", similar concerns would arise in all areas. Therefore, the results from this case study are applicable to the larger research project. Indeed, substantive understanding between perception and environment in this study cannot proceed until these methodological issues are understood and resolved.

This study is also limited by data collection. First, through the survey, participants were asked "Are there any particular places in your neighborhood where you or one of your friends are sometimes afraid to go? If yes, please show me where these places are on the map. Mark these places with an *X*." Given potential for inclusion of a friend's perception, this question may be interpreted as limiting the utility of the response. However, given concern that these male adolescent participants would not feel comfortable admitting to personally experiencing fear, the "friend" enables them to answer the question while maintaining their masculinity. Second, participants were not asked to elaborate on these fear spaces regarding 1) what they fear, 2) why they fear, 3) and if it is constant or tied to particular aspects, such as time of day, or summer versus the school year. As a result, the utility of capturing these environmental perceptions are limited from the perspective of planning interventions. If we do not know what is feared, then it is difficult to intervene or to know if intervention is even possible. Third, no work to date has been published on the influence of base map design on where participants mark their environmental perceptions. For example, does including certain labels or objects, such as parks or major buildings, assist in orienting the participant to the study area, or does it go beyond this role to influence where marks are placed. This is an important question that should be answered to inform future use of this approach.

Finally, the study is limited by data analysis. Although the SIP survey captures data on gang membership status, as well as a wealth of other social and demographic variables, none of these are used in analysis to make any substantive statement on how personal characteristics impact representation of environmental perception on a sketch map. Collective aggregation is applied to all responses, which leads to the ability to see generalities, though perhaps at the expense of other patterns that may have emerged using disaggregation or individual aggregation approaches (Kitchin and Fotheringham 1997). Ultimately, this paper focuses on the currently unaddressed issues of data representation and spatial analysis in how sketch maps are integrated in GIS and this is where it makes its contributions.

Contributions. The purpose of this article is threefold: 1) to examine the ways sketch maps have been integrated with GIS to understand environmental perception, 2) to use the case study of mapping youth fear in Los Angeles gang neighborhoods as a means of demonstrating how this integration can be applied in light of the extant research, and 3) to draw on both the literature and case study to identify problems and prospects of this approach. Therefore, the contributions are presented in these three areas. From the literature, it is clear that integrating sketch maps with GIS is used in a variety of ways to study a variety of subjects. The flexibility of the approach may be a strength, but this flexibility and variety is also a deficit if the details of methods are not reported. Going back to the work of Pockock (1976), Evans (1980), and Blades (1990), it is known that characteristics of participants, base maps, and instructions can influence the resulting sketch maps. Furthermore, from the recent works listed in Table 1 and the case study, it is evident that sketch map data can be represented and spatially analyzed in a number of different ways in a GIS. As there is no standard approach, the details must be reported, from participant characteristics, to base map design, to representation of sketch map data in GIS to the spatial analyses that are performed. Decisions made in each step of the process can propagate through to the final product. Therefore, transparency is essential to understanding the results.

From a technical perspective, perhaps the most important finding of the case study is utility of grid cell aggregation for all vector data models. Indeed, a variety of representations of environmental perception can all be aggregated to grid cells through a spatial join approach and integrated from numerous individuals to create a composite picture of a specific perception. As a result, participants may spatially represent their environmental perceptions in a more organic way; they may mark the map using circles and Xs, as well as lines or other symbology rather than being forced by a researcher to only use a specific representation. All of these sketch map data can be aggregated to a grid of cells across the study area. In effect, this approach to aggregation lessens the burden on a researcher to decide how to represent the data. Of course, GIS is still limited to points, lines, polygons, and grid cells and representing spatial data is still confounded by issues of fuzziness and uncertainty (MacEachren, 1992; Couclelis 2003; Yao, Jiang 2005). However, by using aggregation to grid cells, all of the representations may be used and the researcher is not forced to choose one. Going back to Figure 1, the small *X*s drawn in the middle of roads can be digitized in the GIS as lines or as points, while the larger markings can be digitized as polygons, and they can all be aggregated together. Turning to the spatial analyses performed on the case study data, it is evident that the vector model of representation will impact the types of analyses that can be performed. For example, KDE can only be used for point and line data, while spatial filter is only appropriate for point data. However, returning to the previous point, if participants are permitted to mark perceptual space in a way that is organic to them rather than being forced into a specific representation (e.g. points or polygons), then the spatial analysis method must also accommodate this data collection decision. By aggregating these data to grid cells, the spatial analysis method must operate on polygons and this requirement then leads to a univariate LISA being an appropriate technique. Though Table 1 reports on the variety of representations and spatial analysis methods that have been employed, the grid cell – LISA approach from this case study could be used in all of the previous works. Indeed, it is extensible for showing a composite picture of environmental perceptions and can accommodate a variety of scales (e.g. from micro-environments in parks to the neighborhood level), perceptions (e.g. fear, comfort, stress), and spatial data representations (e.g. however participants mark space).

With the call for greater transparency in how sketch maps are integrated with GIS to understand environmental perception, and the proposal for using a grid cell-LISA method to handle representation and spatial analysis, more basic research in this area is needed as well. Table 3 outlines gaps in research that must be addressed if integrating sketch maps with GIS is to become a meaningful avenue for understanding environmental perception. These needs refer back to earlier work with sketch maps alone (e.g. participants, materials, instructions), as well as their integration with GIS (e.g. representation, spatial analysis).

CONCLUSION

Increasingly, sketch maps are being integrated with Geographic Information Systems (GIS) as a way to understand how people feel about places, especially in urban neighborhoods. This methodological tack is enabled by technical progress in GIS, as well as by an epistemological shift in the use of this technology by scholars in PPGIS and qualitative GIS. The sketch map is re-emerging as a tool to capture the affective side of environmental perception; visualizing and analyzing these data in a GIS is eased by heads-up digitizing and the plethora of spatial analyses available with a few clicks of the mouse. Furthermore, there is intellectual interest in mixing methods, as well as with an environmental design perspective where features of urban neighborhoods can be “designed in” or “designed out” to improve health and well-being outcomes. This confluence of technical and intellectual moments makes sketch map-GIS integration attractive as one way of knowing. However, as demonstrated by review of the extant research and the case study of mapping youth fear from the Social Identity Project, a number of methodological questions are in need of answer, in particular those regarding spatial data representation and spatial analysis. The prospects for this approach are at a fecund point, but are limited by the problems. As noted by Curtis (2012: 182), “though a sketch map may begin as a simple sheet of paper, it is anything but a simplistic approach to accessing people’s feelings about their environment.” When integrating the sketch map with GIS, these complexities are further propagated by the constraints of the software and the decisions made by the researcher. Understanding each of these issues individually and their relationship with each other collectively is essential to effectively integrating sketch maps with GIS to understand environmental perception.

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Table 1. Participant Mapping Methodologies: A Review of the Recent Literature

SOURCE	PARTICIPANTS	DATA COLLECTION	ANALYSIS
Ceccato and Snickars 2000	620 respondents (18-75 years) to a mailed survey on quality of life; the survey included a paper map	particpants given a survey which asked them to define their neighborhood, to identify places they visit regularly, and perceptions of these areas; they could also mark places they avoided	overlay and description of the patterns
Coulton et al. 2001	140 participants (parents of minors) of 7 census block-groups	participants given 11x17inch map with their census block group in the center; 8 mile buffer around this central location; map created in MapInfo; street names and some landmarks were included; instructed to draw neighborhood boundary; data digitized into MapInfo	descriptive categories were created (area, perimeter, centroid, and common area); measures of consensus and comparison to census geography were created and maps analyzed through overlay
Ratcliffe and McCullagh 2001	65 police officers	a series of maps used; asked to indicate areas of high crime for vehicle crime, residential burglary, and non-residential burglary; responses digitized into MapInfo; focus groups gave context to maps	overlay of hotspots of police-perceived crime and computer-generated hotspots of crime incidents; data aggregated to grid cells
Matei, Ball-Rokeach, and Qui 2001	215 participants from seven different ethnic areas; subsample participated in focus groups or mailings where they created "comfort" maps	black-and-white map; colored markers; instructions for color-coding comfort level; digitized into ArcView; participant maps interpreted into grid cells and coded based on color; data digitized into ArcView and overlayed to create collective avoidance maps for specific times	a mean for each grid cell was calculated by adding together all maps and then dividing by the number of maps; spatial regression performed (dependent variable is average comfort level by zip code)
Doran and Lees 2005	234 participants who work in the Central Business District (CBD)	participants were asked to mark on a map of the CBD areas where they feared certain types of crime and therefore avoided the area; they were also asked what time they avoided the area and how hard they tried to avoid the area	visual comparison with physical disorder and crime intensity
Dennis 2006	neighborhood youth	some youth drew maps of the neighborhood to illustrate spatial aspects; youth also took photographs to complement narratives about the neighborhood	description
Campbell et al. 2009	37 adolescents (10-20 years) and 33 parents in for census block groups with varying SES and adolescent outcomes	semistructured interviews began with particpants drawing their definition of their neighborhood on maps that were provided to them; they could also mark issues of concern on the maps	overlay
Veitch, Salmon, and Ball 2008	212 children (8-12 years) from five schools that varied in SES	map of surrounding school area was provided to each student on A-3 paper and a pack of color pens; they were asked to mark X at the following locations and in the assigned colors: black = residence, purple = active play area in past week, blue = playspace most utilized, green = walking/ biking locations in neighborhood with adult; accompanying survey asked them to list the locations they marked on the map	maps used to measure distance from residence to sites of physical activity
Kohm 2009	394 adult participants from a high crime, inner-city area	face-to-face interviews that collected demographic data and used map instrument to capture places in the neighborhood where they felt "unsafe"; 11x17 inch neighborhood maps; instructed to draw circles around areas where they felt unsafe; asked why they felt unsafe in these areas	aggregation of areas of perceived fear were created in ArcGIS (using Platt 2005 method of "topoligcal clean and build"; perceived fear map as ratio with a) signs of disorder and b) crime against the person
Spilsbury, Corbin, and Coulton 2009	60 children (7-11 years) and one parent of each child; 5 study neighborhoods (census tracts); must live in neighborhood for at least 2 months and spend at least 50% of time at home; must speak English	interviews with children (2) and with parent (1); parent given "commercial" map of city and instructed to draw neighborhood boundary; children's neighborhood boundaries collected via "neighborhood walk"; neighborhood boundaries digitized in MapInfo	a variety of quantitative analyses were employed to assess neighborhood boundaries, home ranges, and relationship between parent and child definition of these areas
Lopez and Lukinbeal 2010	388 participants; subsample of 38 participated in mapping exercise as a part of in-depth interview; 5 police officers	base map of neighborhood with 0.5 mile buffer; landmarks included for purpose of orientation; locate residence with "X"; locate neighborhood by drawing circle; color safe areas and unsafe areas using blue and red, respectively; instructions read aloud and discussion of response followed; police mapped high and low areas of crime and described types of crime; scanned and georegistered maps, and digitized data in ArcGIS 9.x	aggregated data to parcels; mapped percentage of perception and overlayed with police perception of crime
Wridt 2010	32 fifth grade students (10-11 years)	children marked (with markers and stickers) locations related to physical activity on 1.3mx1.5m aerial photographs; photos were covered in acetate for repeat use; each student used own map, different color markers for different themes, and provided brief annotation of marked features; students used logs for more detail about each marked location	map student locations related to physical activity and overlay

Table 2. Summary Participant Fear Spaces

FEAR SPACES (N)	PARTICPANTS (N)	MEAN (m)	MEDIAN (m)
1	11	78070.11	11151.84
2	8	37816.66	9075.68
3	9	42838.29	4399.87
4	5	3740.61	2492.93
5	2	4199.50	2452.82
6	1	137386.61	121511.38
7	4	11853.51	3379.13
8	1	40447.81	39201.50
9	3	28595.75	2500.28
10	1	1288.04	1222.87
11	3	18627.57	1424.63
13	2	2657.86	2667.18
14	1	4133.21	4044.81
16	1	1029.61	986.65
23	1	21721.90	13508.70
29	1	2121.69	1928.43
34	1	3995.19	3852.84
39	2	3933.34	3330.60
51	1	787.87	809.16

Table 3. Future Research Needs

DATA COLLECTION:
Participants *Residential history:* affect familiarity and experiences in the present environment *Age and level of education:* influence level of graphicacy
Materials *Paper size:* map area and scale: influence on degree of detail *Map features:* may bias results (e.g., inclusion of schools, parks, liquor stores, etc.) *Map type (source):* familiairty with a widespread map style (e.g. Google Street Map) may influence level of graphicacy
Instructions *Spatial representation (instructed or organic):* only points or only polygons may not capture space of environmental perception of participant *Qualitative description:* provides explanation or context for perception
INTERPREATION:
Symbology: What do particpants mean when they use a X? *Fuzziness:* How fuzzy are their marked spaces? How can they be instructed in order to capture fuzziness?
ANALYSIS:
Digitization method: are paper maps georegistered first or are spaces digitized based on reference to existing layers (e.g. roads) *Vector model:* points, lines, or polygons each convey different meanings of space, as well as enable different analysis methods *Analysis justification:* should be undertaken based on hypothesis about the relationship between the underlying geography and perception

Figure 1a. Example of participant-defined fear space as one large *X*. **Figure 1b.** Example of participant-defined fear space as a series of small *X*s.

Figure 2a. Polygon interpretation of participant-drawn fear spaces. **Figure 2b**. Point Interpretation of participant-drawn fear spaces.

Figure 3. Relationship between number of fear spaces and size of fear spaces

Figure 4. "Heat map" of fear spaces aggregated to parcels: a) points and b) polygons

Figure 5. "Heat map" of fear spaces aggregated to parcels: a) points and b) polygons

Figure 6. Results of univariate LISA

Figure 7. Figure 7. Results of hot spot analyses on point data: a) KDE, and b) spatial filter

Figure 1a. Example of participant-defined fear space as one large *X*. Figure 1b. Example of participant-defined fear space as a series of small *X*s. The inset map in each image demonstrates how the hand-drawn marking was represented in GIS, as point and as polygon.

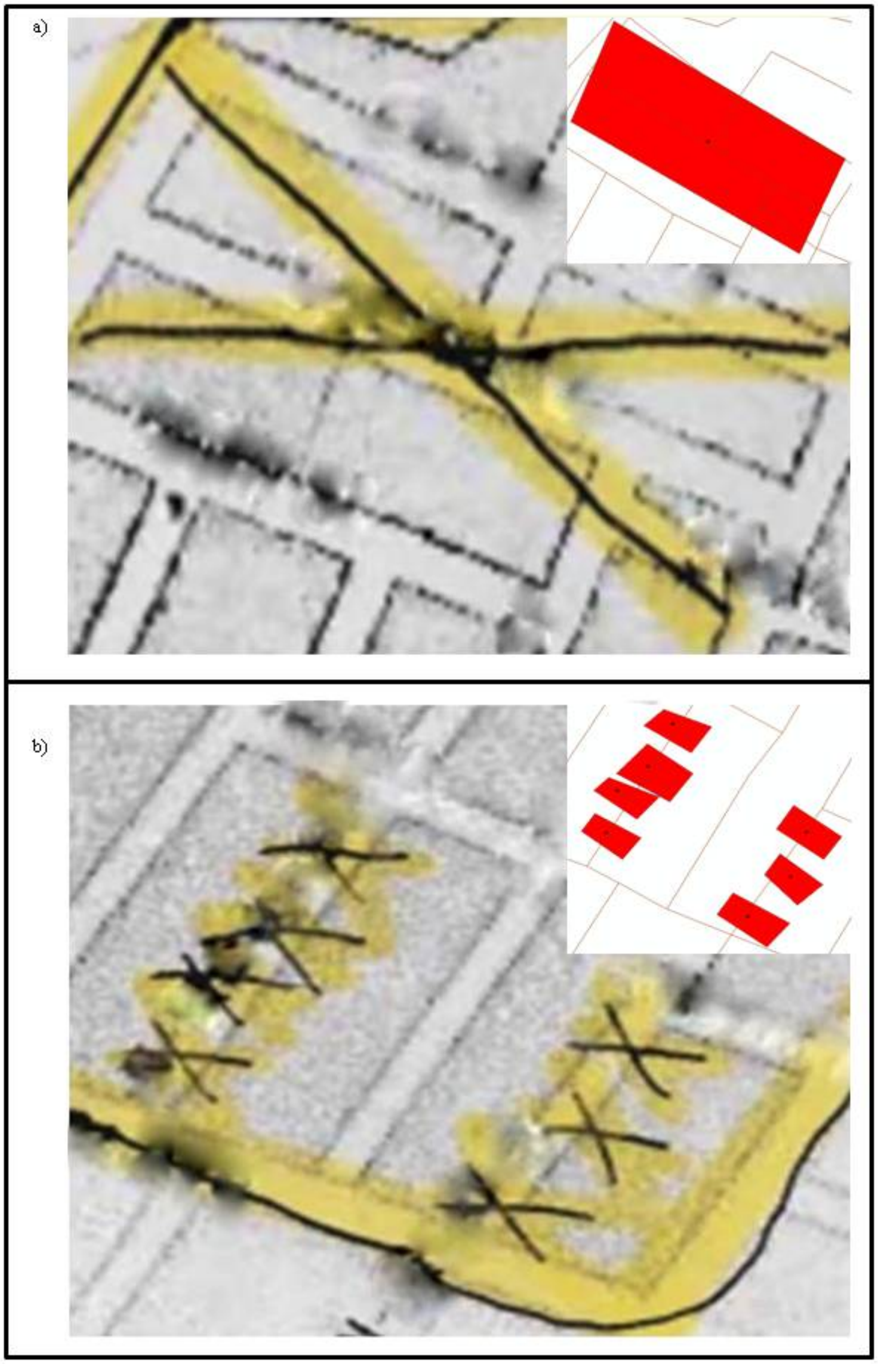

Figure 2a. Polygon interpretation of participant-drawn fear spaces. Figure 2b. Point Interpretation of participant-drawn fear spaces.

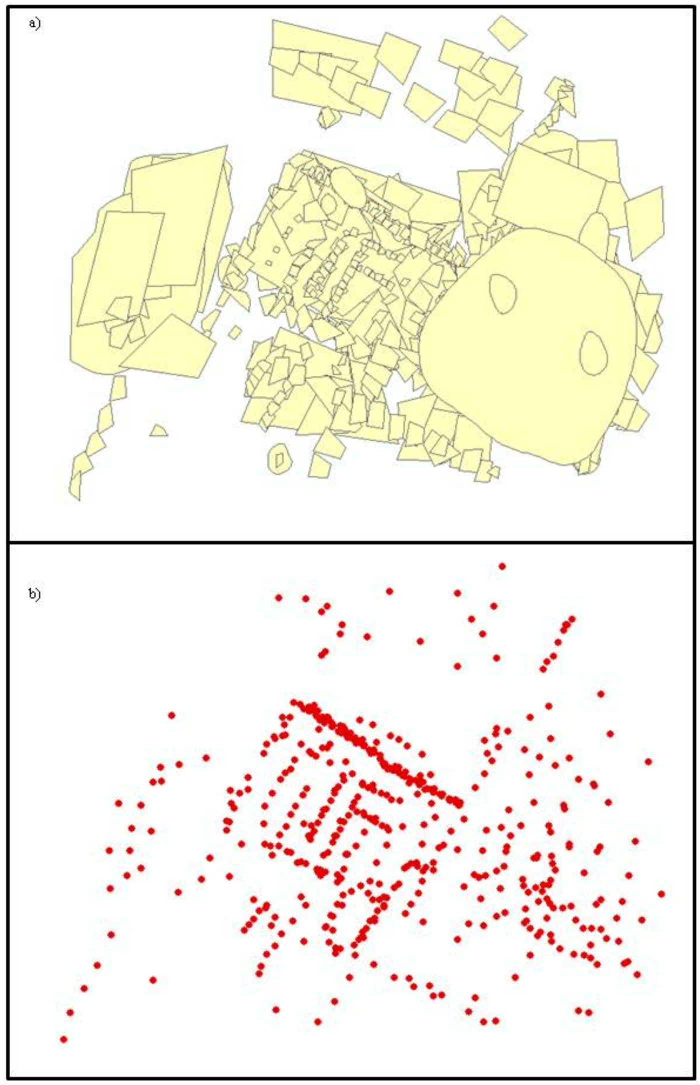

Figure 3. Relationship between number of fear spaces and size of fear spaces

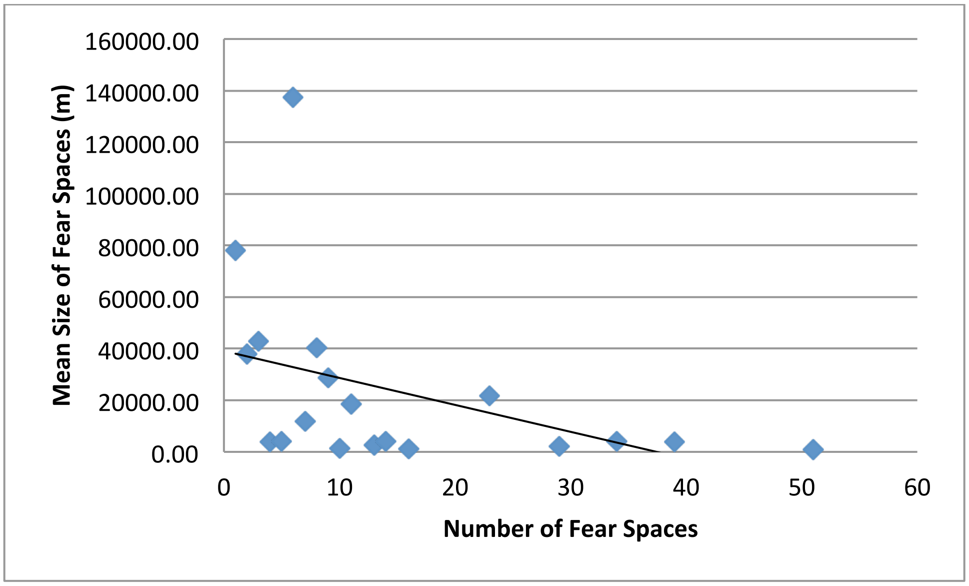

Figure 4. "Heat map" of fear spaces aggregated to parcels: a) points and b) polygons. Colors range from light yellow to red based on the percentage of participants' fear spaces that intersect each grid cell (low to high), respectively.

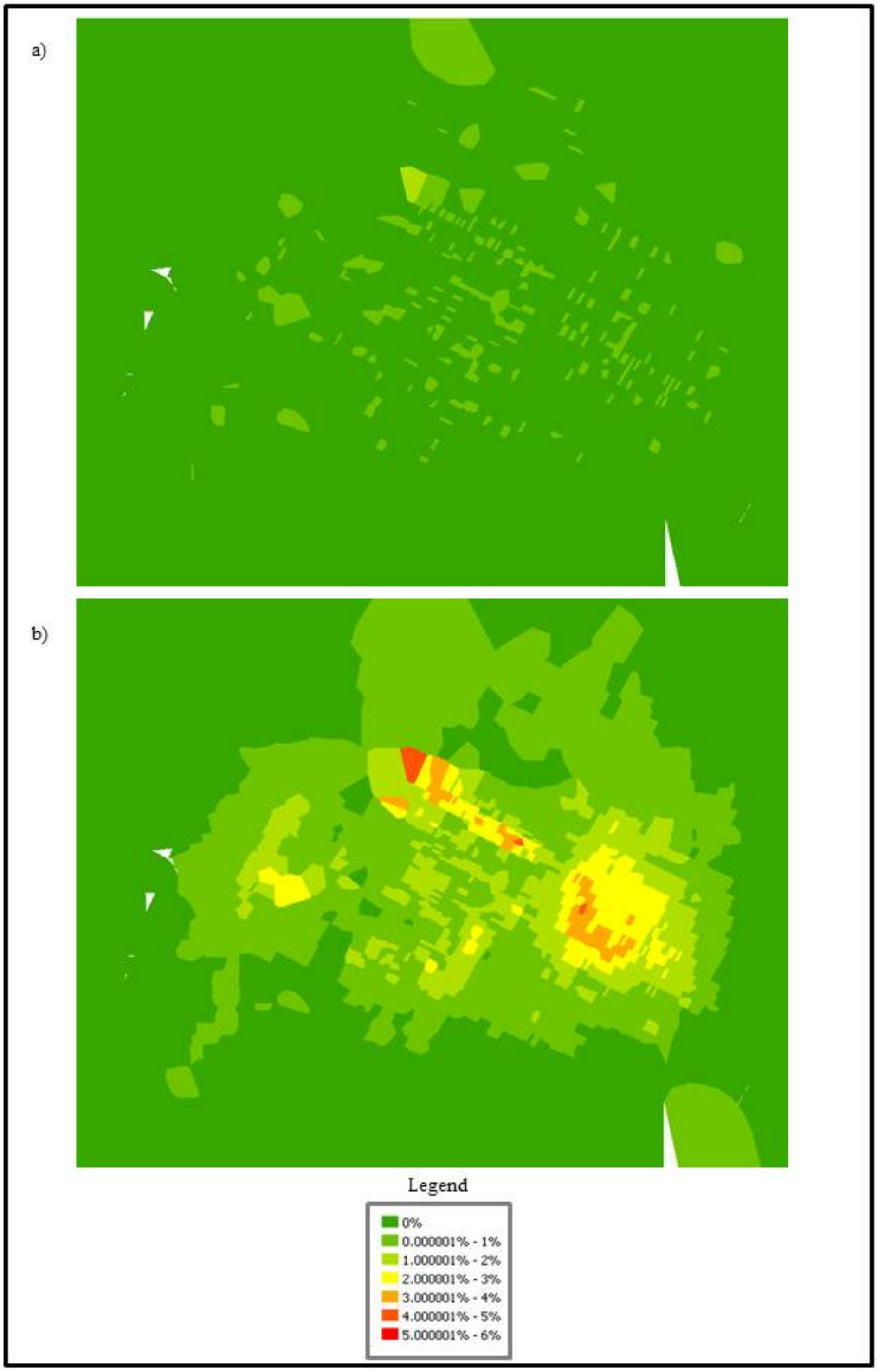

Figure 5. “Heat map” of fear spaces aggregated to grid cells: a) points and b) polygons. Colors range from light yellow to red based on the percentage of participants’ fear spaces that intersect each grid cell (low to high), respectively.

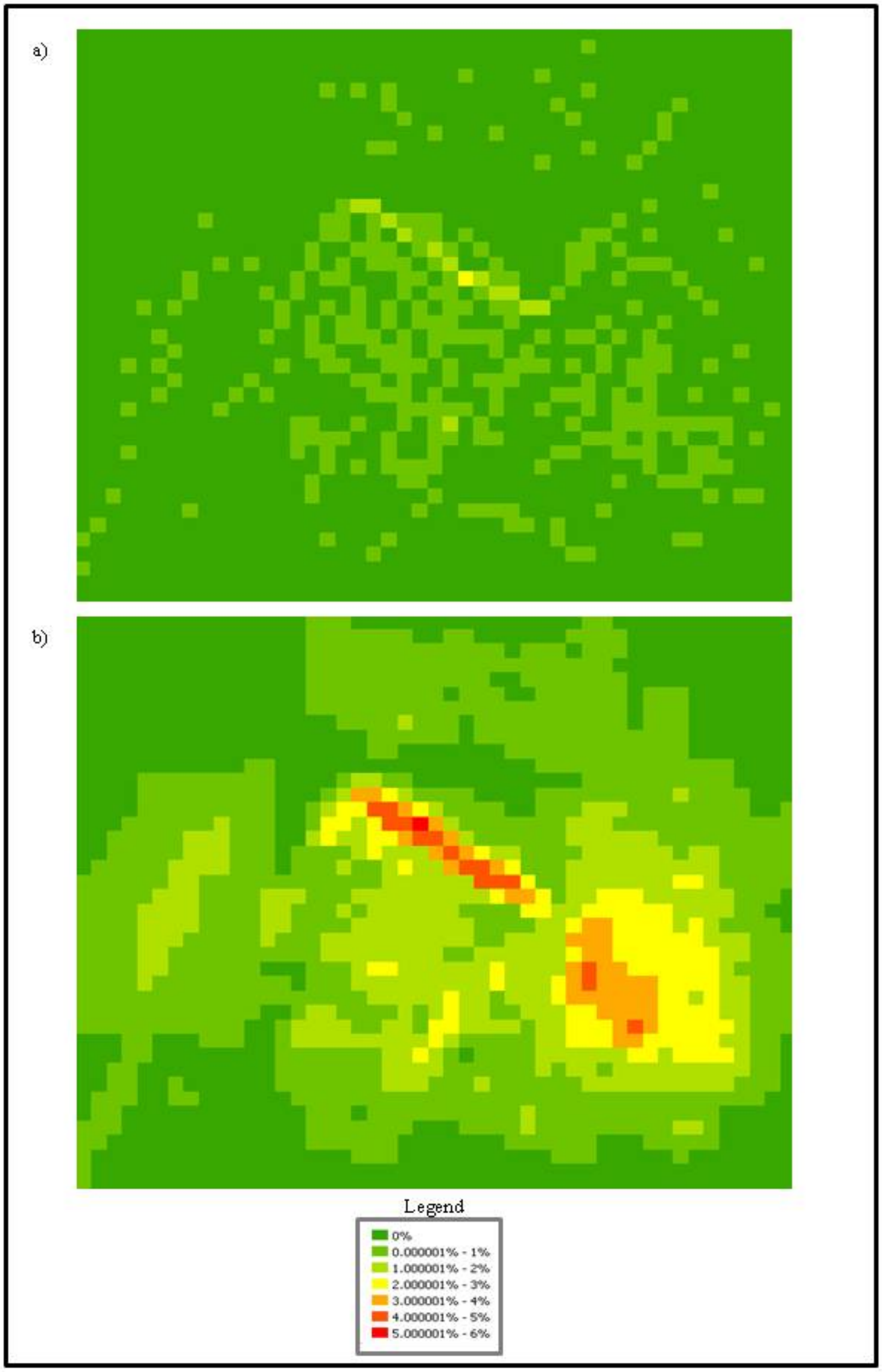

Figure 6. Results of univariate LISA

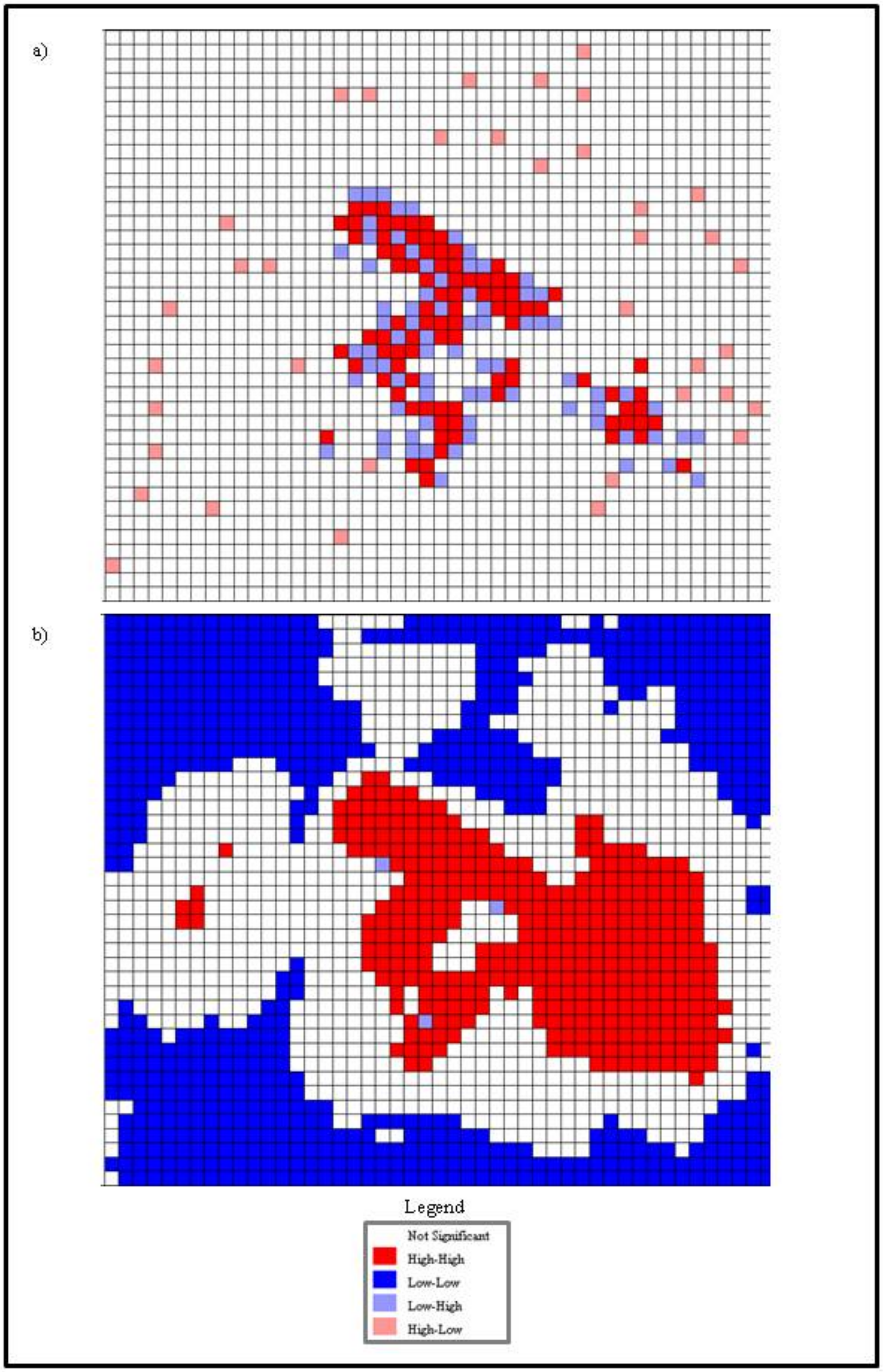

Figure 7. Results of hot spot analyses on point data: a) KDE, and b) spatial filter