Understanding Spatio Temporal Patterns of Crime Using Hotspot AND Coldspot Analysis

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Summary

This paper argues that we need to think as much about where crime does not happen as where it does. The use of hotspot maps is a widely accepted practice in policing, These maps highlight areas with high concentrations of crime but tell us less about areas with medium or low concentrations of crime. Understanding what makes a 'low crime place' may provide lessons for reducing crime. This paper proposes techniques which use a mixed method approach, combining LISA, Group Trajectory Analysis and Focus Groups, to give us a more nuanced and detailed understanding of crime at the neighbourhood level.

KEYWORDS: *Hot and Cold Spots; Mixed Method Spatio Temporal Analysis; Vandalism*

1. How best do we view neighbourhood crime?

Robert Sampson argues that:

> "[Ne]ighborhoods vary in size and complexity depending on the social phenomenon under study and the ecological structure of the larger community..."(Sampson,2012,54).

Thus there is no one single scale that represents a neighbourhood. The Modifiable Areal Unit Problem (Opensahw, 1984) tells us that our choice of scale will affect the results of our analysis. This presents a particular challenge for representing neighbourhood level crime using maps; what scale(s) should we use? Weisburd and colleagues reveal considerable variation in trajectories of crime at the street segment level (Weisburd et al, 2012). Taylor argues for the use of multiple scales, taking both a top down and a bottom up view of crime (Taylor, 2010).

2. How do patterns of crime change over time?

Routine activity theory (Cohen and Felson, 1979) suggests that concentrations of crime are related to individual's routine behaviours. Routine behaviours can change over time across months, years and decades. Each of these activity changes can also impact on local levels of crime. This means we need to reflect temporal change in our crime maps too.

3. The Case Study

Here we assessed whether different local areas had consistently high or low levels of vandalism across time. Vandalism was chosen as it has rarely been the focus of research in recent years but remains a volume and signal crime impacting negatively on local communities. Focusing on a specific crime potentially reduced the complexity of possible explanations of crime concentrations.

3.1 The Study Area, Data and Scale

The study area was within the city of Edinburgh, managed by a single senior police officer, with a mix of physical and socio-economic environments. The data used were individual locations of recorded crimes of vandalism across a six year period from 1st April 2004 to 31st March 2010, along with qualitative data generated in focus groups. Recorded crime data were aggregated together into

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financial years (1st April to 31st March) at 100m by 100m grid square, data zone and output area.

3.2 What methods could allow us to explore hot and cold spots of crime across time?
This paper used three methods to explore levels of crime in local neighbourhoods:

- '*Talking to the map*' - Community police officers and their senior officer were invited in three separate focus groups to annotate maps. They were asked to shade maps based on their local knowledge and share their understanding and experience of the characteristics of crimes of vandalism. This technique was developed based on previous work which had asked police officers to designate areas of high crime (Ratcliffe & McCullagh, 2001; Craglia et al, 2005, Haining, 2007) and using participatory GIS to elicit resident perceptions (Cinderby, 2009).

- *Local Indicators of Spatial Association (LISA)* – two indicators were used: Local Moran's I (Anselin, 1995; Assunção and Reis, 1999) and G_i* (Getis & Ord 1992; Ratcliffe & McCullagh, 1999). Data were assessed for recorded crimes over six financial years.

- *Group Trajectory Analysis* using aggregate geographic data – This technique was adapted from work done by Groff et al, 2010.Two types of technique were used at two different scales. At 100m grid a negative binomial count model was used. At output area a categorical model was used to assess whether areas had constantly average levels of vandalism, around average or below average groups across time.

The *Talking to the Map* approach had the advantage that it did not rely on the choice of any predefined scale and allowed participants in the exercise to create their own boundaries. It enabled commentary by participants to be closely linked to places and specific locations. Limitations: 1) participants were constrained as they were asked to shade a pre-existing map; 2) the areas labelled as high or low crime areas relied upon police officer's personal knowledge and experience so may have been subject to bias and 3) the total number of focus groups was small.

Using *LISA* had the advantage that it provided a method of visualising statistically significant both hot and cold spots simultaneously; the method took direct account of spatial autocorrelations and results were relatively easy to present and explain to police officers. Limitations: 1) data was subject to the small number and multiple testing problems (Haining, 2003) which could only be partially resolved and 2) it did not provide a method of summarising crime trajectories.

Using *Group Trajectory Analysis (GTA)* enabled distinct trajectories across time to be assessed. It was possible to identify high, medium and low concentrations of crime at two scales, with two different methods. Limitations: (1) the technique did not control for spatial autocorrelation, (2) the small number problem was only partially resolved.

Additionally these techniques were combined in two key ways which added value and allowed triangulation of results:-

- *Combining officer knowledge with LISA maps*.

- *Comparing results of office focus groups, LISA and GTA*.

Combining these techniques created a rich set of results which provided far more insights than could have been achieved by one method alone and enabled rich insights into possible drivers of change across time.

4. Key results

Choice of Scale has a notable impact of processes observed in visualisation. Certain scales appear to show different types of crime concentrations more clearly. This was apparent by comparing high and low concentrations of crime identified by focus groups with LISA analysis. Officers in Focus groups used a combination of fill in shading and outlines for high crime concentration areas (pink), and primarily outlines only for low areas (blue). The types of high area highlighted, varied from single roads and building complexes, to whole estates, low areas were often larger (Figure1; Figure 2). This raises the possibility that different processes may be operating at different scales.

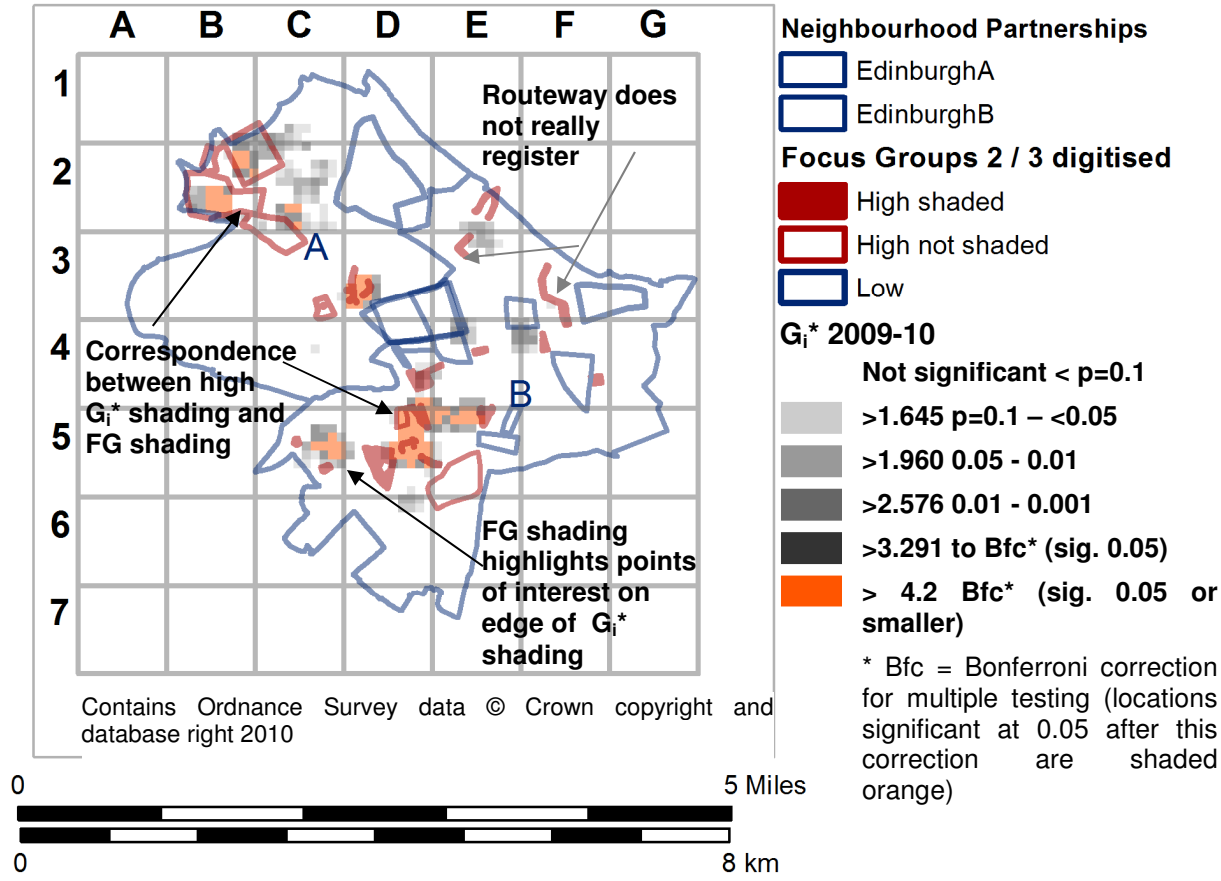


Figure 1: G_i*results for a single year of aggregate crime at 100x100m Grid scale compared to digitised focus group (FG) shaded maps

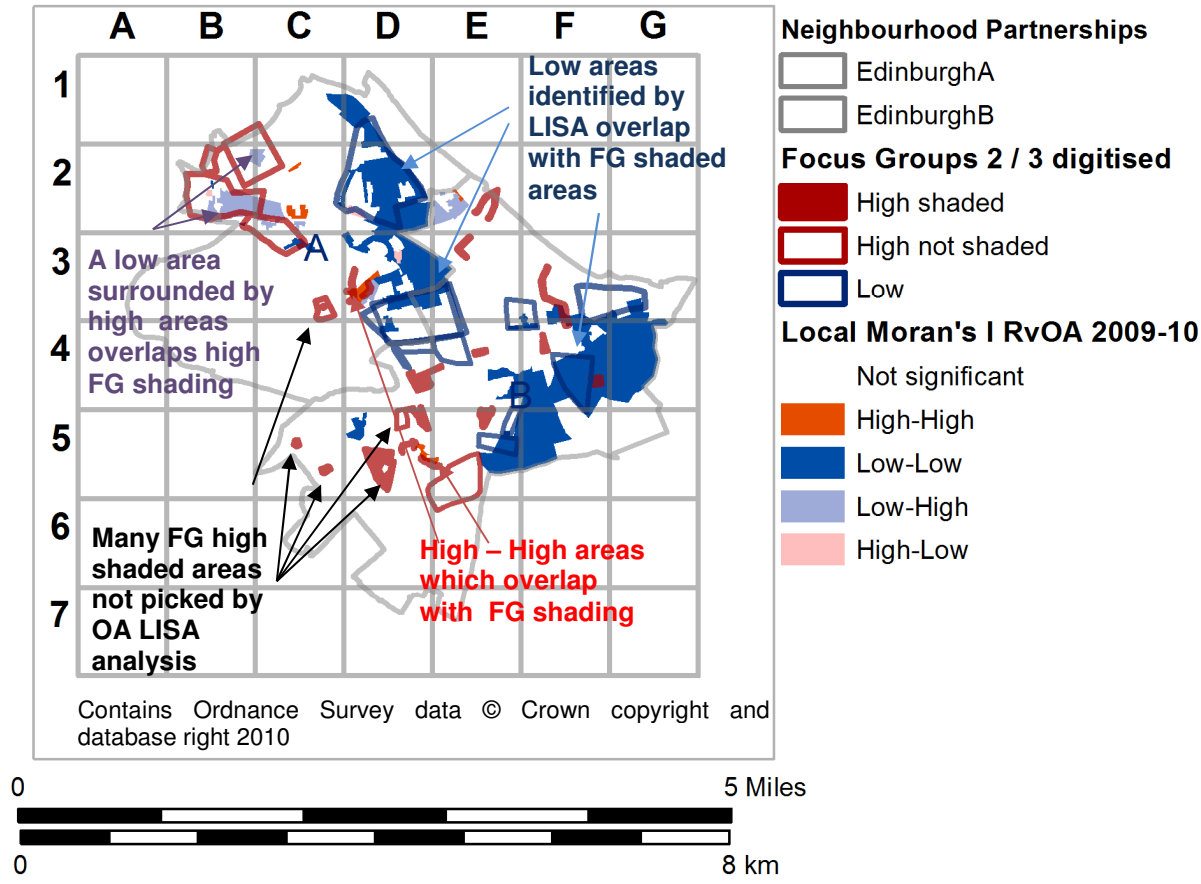
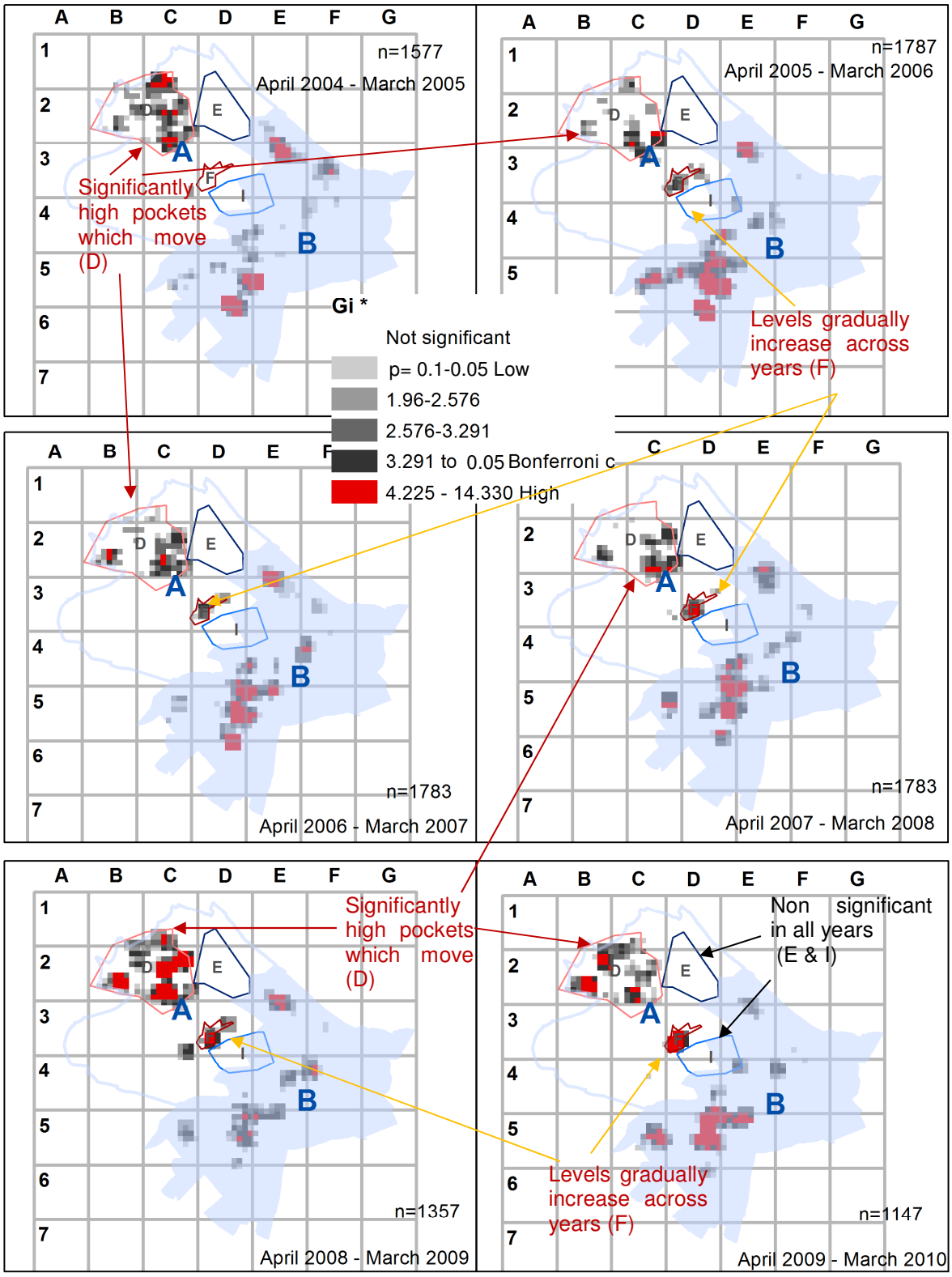


Figure 2: Local Moran's I analysis for a single year at Output Area (OA) scale compared to digitised focus group (FG) maps

GTA provided increased descriptive and potential explanatory power, especially when combined with results of spatial analysis (LISA) and information from focus groups. This was important in identifying high, low and 'drifting areas' – pockets that move over time. Figure 3 is an example of Gi* analysis with these identified areas overlaid – D – Delta is Drifting High Area, Indigo I a Drifting Low Area; F – Foxtrot a High Area and E- Echo a consistently low area.

Figure 4 shows complementary of Group Trajectory results with these same areas overlaid. GTA found 4 distinct groups of areas with similar trajectories of changing levels of crime across time were identified at OA level and 6 groups at Grid level (just the 3 high groups are shown here).



All Vandalisms - Vandalism, Malicious Mischief and Fire-raising

Figure 3: Vandalism in micro-neighbourhoods across the study period in EdinburghA using Gi* (row standardised z-scores – Bonferroni correction – significant at 0.05 areas shown in red)

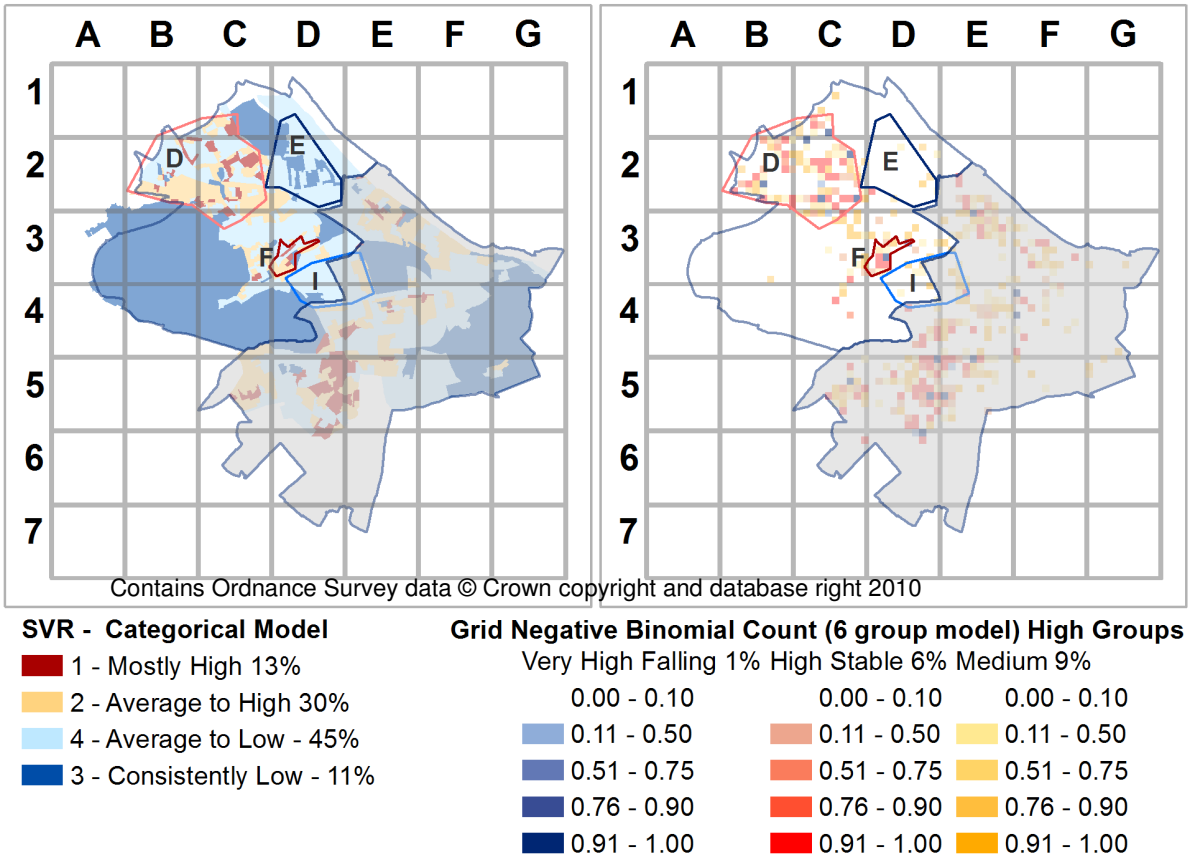


Figure 4: Results of Group Trajectory Analysis with areas identified from combined analysis D,E,F and I overlaid

5. Key outstanding challenges

High, Low and Drifting areas had distinct and interesting characteristics; this suggests analysts need to move to using techniques which allow them to identify not only crime hotspots but coldspots and the areas in between.

This analysis suggests we ideally need to analyse data at multiple scales (and clearly state limitations when we use a single scale). More profoundly different results, observed at differing scales, may reflect the impact of differing external processes on high, low and drifting concentrations of crime. Should we model at two or more scales simultaneously? If so, how do we visualise the results of this multi-level analysis?

Modelling this type of data is challenging. No single technique presented here fully takes account of common methodological issues. Combining techniques assists but each still has limitations in one or more areas. More complex modelling strategies may be needed; a further key challenge will be developing the skill base for complex models to be understood and interpreted in a way that is accessible to a lay audience.

Biography

Ellie Bates is an AQMeN research fellow in criminology interested in crime and place. William Mackaness is a senior lecturer specialising in visualisation methodologies and GIS.

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