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Spatial conjunctive analysis of (crime) case configurations: Using Monte Carlo methods for significance testing

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ABSTRACT

While research has repeatedly demonstrated how spatial distributions of crime can be shaped by the presence of facilities such as bars and public transport hubs, the *joint* influence of different facility types has rarely been explored. Spatial conjunctive analysis of case configurations (also known as qualitative comparative analysis) offers a means to identify the combinations of facility types that are most commonly found around crime events, and has been used in a small number of studies focusing on street robbery. This study extends this limited evidence base by implementing a significance test based on the Monte Carlo method using street robbery data for Austin, Texas. The results show that some of the top-ranking facility type combinations had observed frequencies that were not significantly greater than chance expectations. The accurate identification of the highest-risk environments has important implications for crime prevention.

1. Introduction

Understanding the factors behind the spatial patterns of crime has important implications for crime prevention and detection. We have known for decades that crime is not randomly distributed in space, but rather that there are certain locations that are associated with higher crime volumes (e.g., Eck & Weisburd, 1995; Nelson, Bromley, & Thomas, 2001). Several explanatory factors have been shown to contribute to such increased crime levels, including certain socio-demographic neighborhood characteristics (e.g., Sampson, 1985; Sampson, Morenoff, & Gannon-Rowley, 2002), land use designations (e.g., Boessen & Hipp, 2015; Browning et al., 2010; Kinney, Brantingham, Wuschke, Kirk, & Brantingham, 2008), and proximity to facilities such as public transport hubs, alcohol outlets, and neighborhood parks, to name but a few (e.g., Barnum, Caplan, Kennedy, & Piza, 2017; Block & Davis, 1996; Conrow, Aldstadt, & Mendoza, 2015; Groff & McCord, 2012; Summers & Johnson, 2016). Most of the studies in the latter category have focused on just one type of facility, or examined the independent influence of each facility type within a multivariate model. However, many of these facilities are often near one another, and it is possible their joint influence might lead to interactions, instead of simple additive effects.

In an attempt to explore this issue, Hart and Miethe (2014, 2015) employed (spatial) conjunctive analysis of case configurations (CACC; also known as qualitative comparative analysis or QCA) to identify the specific configurations or combinations of facilities that are associated with high crime levels, using street robbery data from Henderson, Nevada. As predicted, street robberies were found to be clustered around a relatively small number of "situational profiles" (i.e., specific combinations of activity nodes or facilities), and the effect of individual facility types, such as bus stops, appeared to be moderated by the presence of other facility types nearby.

Although Hart and Miethe (2014, 2015) were able to identify the configurations of facilities that were most commonly found near street robbery events, no counterfactual was available that would enable a conclusion being reached about the actual *risk* associated with such configurations. That is, the question remains as to whether high crime counts were observed for certain configurations due to these being criminogenic, or simply due to such configurations being more prevalent in the environment considered.

The current research aims to replicate and extend Hart and Miethe's (2014) study by performing similar CACC analyses using street robbery data for Austin, Texas, but also implementing a Monte Carlo test to compare the observed crime frequencies to a random sample distribution. The aim here is to determine which

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facility configurations have associated crime counts that significantly depart from what would be observed by chance, given the actual spatial distribution of facilities over the urban landscape.

The paper is structured as follows. The first section provides a brief overview of the literature that has examined the influence of land use and facilities on the spatial distribution of crime. We then move onto the spatial CACC analyses performed by Hart and Miethe (2014, 2015), and a concise discussion on the use of statistical testing in spatial CACC. At this point, Monte Carlo methods are briefly reviewed, with an emphasis on how they can be used to study crime patterns. The research questions for the present study are then clearly stated and this is followed by a detailed exposition of the data sources and methods employed. Next, the results and discussion are jointly presented, emphasizing the implications of the findings for theory, future research, policy, and practice. It is hoped the findings from this research help strengthen the existing evidence base and inform police resource allocation strategies and city planning.

2. Spatial concentrations of crime, the influence of facilities, and theoretical framework for the study

Research has consistently demonstrated that street robberies, and crime in general, are not randomly distributed in space (Braga, Hureau, & Papachristos, 2010; Eck & Weisburd, 1995; Johnson, 2010; Nelson et al., 2001; Sherman, Gartin, & Buerger, 1989; Weisburd, Bushway, Lum, & Yang, 2004; de Melo, Matias & Andresen, 2015). Such patterns can be explained by the routine activity perspective and crime pattern theory in that they both articulate how the physical environment enables and/or promotes criminal activity. The routine activity perspective (Cohen & Felson, 1979) considers how individuals' everyday routines may bring suitable targets in contact with motivated offenders in the absence of capable guardians, thus providing opportunities for crime to occur. Crime pattern theory (Brantingham & Brantingham, 1984) builds on the routine activity perspective and argues that crime is likely to occur where offenders' awareness spaces overlap the areas where crime opportunities exist (offenders' awareness or familiarity surfaces are shaped by their routine activities and are usually centered around their homes and other significant activity nodes such as city centers and other commercial districts).

Offender interview research generally supports these two theories. For example, robbers state they often commit robberies when they encounter “opportunities that seemed too good to pass up” (Wright & Decker, 1997: 34). These same active street robbers explained how they tended to seek out areas with many people, such as malls, as these provided multiple targets from whom to choose. Wright and Decker (1997) also reported that most of the robbers they interviewed committed their crimes within their awareness space, which tended to cover their home neighborhood and other areas they often frequented, supporting the idea that a robber's daily routine impacts the opportunity for crime.

Similarly, analyses of police-recorded crime data have shown that street robbery often clusters around public transport hubs (Block & Davis, 1996; Kooi, 2013; Newton, Partridge, & Gill, 2014; Stucky & Smith, 2014) and commercial land uses such as shopping centers, bars, restaurants, grocery stores, and gas stations (Bernasco & Block, 2011; Groff & Lockwood, 2014; Lockwood, 2007; Toomey et al., 2012). Bernasco and Block (2011) detected an increased risk for robbery not just on the street blocks containing the crime generators and attractors considered, but also in the blocks directly adjacent to these. The conclusion from these and other research studies is that street robbery, like other crime types, is highly clustered in space, and that such clusters are related to offender awareness spaces, general urban population movements, and the urban landscape that underlies and shapes such movements.

2.1. Crime generators and crime attractors

The facility types considered in the studies just described are examples of what Brantingham and Brantingham (1995) define as crime generators and crime attractors. Both crime generators and crime attractors are associated with higher crime counts, but the mechanisms for each are different. The increases in crime associated with crime generators are simply due to the greater volumes of people (including offenders) that congregate around them for reasons unrelated to crime (e.g., bus stops, train stations, shopping districts, etc.); while offenders are there, they may become aware of and take advantage of crime opportunities that arise, but committing crime would not have been the motivation for the offender to travel to such a location in the first place. In contrast, crime attractors are places that are known to offer crime opportunities, so that offenders travel there with the explicit intent to commit crime (e.g., drug markets). Often, what may be initially regarded as a crime generator becomes a crime attractor, if an offender targets the place specifically when searching for potential crime victims (e.g., an offender travels specifically to an entertainment district to search for possible individuals to rob).

While the probability that potential targets and motivated offenders converge in space and time is higher in busy places, so is the probability of a capable guardian being present, at least at certain times of the day. For this reason, robberies sometimes do not occur in these (potentially) busy spaces, but rather a short distance away, where guardians are not as likely to be encountered (e.g., Bernasco & Block, 2011). Such places were designated “critical intensity zones” by Angel (1968). A typical scenario might involve an offender identifying a potential victim within a busy location, where a large victim pool exists, and then following them to an isolated area nearby where there is less guardianship and where the attack can be more safely carried out.

With a few exceptions (e.g., Deryol, Wilcox, Logan, & Wooldredge, 2016), research has tended to evaluate the effect specific facility types have on the spatial distribution of crime *independently of other types of facilities*, typically using various types of regression analysis. This approach, while useful, fails to consider possible interactions between multiple facility types. It is possible that different types of criminogenic facilities have an additive effect, a multiplicative effect, or no net effect on crime (e.g., because too many, or certain combinations of, facility types draw too big a crowd which is not conducive to robbery). However, modeling such interactions within a regression analysis framework is problematic in that three-way and higher-order interaction terms are difficult to interpret. The inclusion of such terms in a model can also lead to multicollinearity, loss of statistical power (unless a sound justification can be provided for examining only a proportion of all possible interactions), and other analytical issues.

2.2. Using conjunctive analysis to examine the joint influence of various facility types

An alternative approach was put forward by Charles Ragin in the 1980s in the form of qualitative comparative analysis (QCA; Ragin, 1987/2014). Also known as conjunctive analysis of case configurations (CACC), the method is grounded in multiple conjunctural causation, which suggests that: “(1) most often, it is a combination of conditions that generate an outcome; (2) several different combinations of conditions may produce the same outcome; and (3) a given condition may have a different impact on the outcome depending on the context” (Ragin, 1987/2014: xxii). CACC is a