Criminal directionality and the structure of urban form

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A R T I C L E  I N F O

Article history:
Available online xxx

Keywords:
Directionality
Geometry
Spatial analysis of crime

A B S T R A C T

Spatial criminology has three interrelated elements: place, distance, and direction. Though directionality has had theoretical support for many years, very few empirical verifications of this component of crime have emerged. In this article, we investigate the strength of directionality by comparing a simulated randomized dataset and a large incident-based dataset of repeat offenders. We find strong evidence for a strong presence of directionality in criminal spatial decision-making. This aspect of the spatiality of crime must be considered in any attempts to understand the aetiology of crime.

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1. Introduction

Spatial criminology has a history dating back 175 years to the moral statistics of Quetelet (1831, 1842) and Guerry (1833). With subsequent interest in the spatial dimensions of crime in 19th century England (Glyde, 1856), early 20th century North American social disorganization theory (Burgess, 1916; Shaw & McKay, 1931, 1942), and current environmental criminology (Brantingham & Brantingham, 1981; Clarke & Cornish, 1985; Cohen & Felson, 1979), one cannot deny the importance of spatial criminology to understand the aetiology of crime—see Wortley, Mazerolle and Rombouts (2008) for a recent collection of essays. These spatial criminological theories have proven successful in explaining crime patterns, helpful in understanding individual victimization, and relevant to crime prevention/reduction activities. As such, investigations into the fundamental concepts of these theories are important for academics and practitioners to better understand the spatial nature of criminal activity. Indeed, our understanding of the spatial dimension of crime has made great advances in recent years (Ratcliffe, 2002).

Within the spatial analysis of crime, the decision-making process of individuals involves three interconnected and fundamental elements: place, distance, and direction. The first two of these elements (place and distance) are well-researched within criminology. Recent developments for place form a “crime at places” literature.1 The crime at places literature argues that micro-places such as street segments or street corners are key to understanding criminal activity. The journey to crime (distance) continues as a focus in spatial criminology. Assuming the decision-making process to commit a crime begins at the home location, the “journey to crime” can be relatively short. This assumption may be problematic because the journey to crime may start from place other than the home (Townsley & Sidebottom, 2010). If this is the case, much of the inference based on this research may be misleading. However, this assumption is made because of data limitations. Police records that have information on offenders will only have their home address. Only detailed interview data would be able to contain such details. With this criticism in mind, the journey to crime being short has been supported in number studies for locations in both the United States and Europe. The trip (distance from home) varies from crime type to crime type, by age of the offender, by location of potential targets, by mode of transit, but tends to be short (Bernasco & Block, 2009; Castano, Halperin, & Gale, 1986; LeBeau, 1987; Phillips, 1980; Pyle et al., 1974; Wiles & Costello, 2000)—see Bernasco (2006) for a comprehensive review in the context of burglary. Also, see van Koppen and De Keijser (1997) and Rengert, Piquero, and Jones (1999) for discussions on the issue of distance decay function as a representation of the rate at which offending decreases as the distance from home increases.

Directionality, however, is an under-researched area in criminology. White (1932), Brantingham and Brantingham (1981, 1984), Rengert and Wasilchick (1985) and Ratcliffe (2006) approach the directions and paths people use to move from one activity node to another. Because of the constrained nature of our (built) environment, we normally develop routines between frequently visited destinations. The trips between home and work or work and entertainment areas have a directional orientation; we routinely travel along routes that are directed towards our destinations. Despite this importance of directional knowledge/information, there

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are only two theories and a small number of empirical investigations that consider direction in the (spatial) criminological literature.

2. Directionality and crime: theory and evidence

The theoretical foundation for the presence of directionality in criminal activity is the geometric theory of crime (Brantingham & Brantingham, 1981, 1984, 1993) and temporal constraint theory (Ratcliffe, 2006). The theoretical work of the Brantinghams has its roots in the work of Lynch (1960), who described the ways in which we move through our (urban) environment. The most important concepts from this work for understanding directionality in criminal behaviour are nodes and paths. Simply put, nodes are those places in our environment that we travel to and from: home, work, school, recreation sites, entertainment, and shopping; paths are the vectors that we move along to get from one node to the next: most often, these paths are roads and walkways. Put together, nodes and paths comprise the areas within our environment that constitute our activity and awareness spaces, because this is where we spend most of our time.

Brantingham and Brantingham (1981, 1984, 1993) represent these spaces as maps that can then be used to illustrate why we would expect directionality in criminal behaviour. Fig. 1 shows two cases: 1) strong directionality and 2) weak directionality. In the case of strong directionality, the vast majority of a person’s activities are contained within a 45° angle. As such, if crime is (partially) the result of opportunities that arise because of non-criminal activities (Brantingham & Brantingham, 1981, 1984; Cohen & Felson, 1979; Felson & Cohen, 1980, 1981), such a person’s criminal activities will also be contained within a 45° angle. In the case of weak directionality, this person’s activities are in all directions such that a priori no directional bias can be expected.

A consequence of considering these two forms of activity space is that the strength of directionality, in general, is going to depend on the relative frequency of strong and weak directionality activity spaces in the general population. However, if the majority of people’s activities are concentrated along one particular vector (work or recreation, for example), directionality will be present. This, of course, is an empirical question.

Temporal constraint theory (Ratcliffe, 2006), as the name suggests, outlines the important of time when trying to understand criminal activity. Temporal constraint theory not only shows the importance of time, but that time and space are intimately related: because of temporal constraints, we constrain our movements through space. In fact, Ratcliffe (2006) develops maps based on temporal constraints that are quite similar to the awareness space maps of Brantingham and Brantingham (1981, 1984, 1993). Consequently, in order to consider our temporal constraints, we must choose our direction carefully.

Rengert and Wasilchick (1985) is the first piece of research to investigate empirically the strength of directional bias in criminal behaviour, specifically burglary.2 They find that more than 50 percent of burglary crimes occur within a 45° angle from the home location of the offender—12.5 percent of the potential use of space. Moreover, when burglars who also have legitimate employment are considered, upwards of 75 percent of crimes are contained within a 45° angle; most of the burglaries are just beyond the work place or along the pathway between work and home. When other spatial knowledge of burglars is considered (location of fence, friend’s residence, or other recreation sites) the search pattern is less directional but a distinct directional bias is still present.

Following this initial work by Rengert and Wasilchick (1985), there has been relatively little research on the issue of directionality in criminological research; in fact, we are only aware of five other pieces of research on this subject matter. Immediately following the work of Rengert and Wasilchick (1985), Castanzo et al. (1986) test whether offenders who live near one another travel in the same direction to commit their offences. They find that regardless of the crime classification offenders that live close to one another move in similar directions to commit their offences. Only considering serial murderers, Godwin (2001) and Lundrigan and Canter (2001) find that serial murderers are directionally biased for not only target selection, but also the disposal of bodies. Goodwill and Alison (2005), investigating serial homicide, rape, and burglary, not only find a strong directional bias, but the strength of this directional bias varies by crime type: it is strongest for burglary, then rapists, and murderers—the majority of burglars and rapists select their targets within a 90° angle.

The difficulty with this discussed research, particularly the very early work, is the size of their samples. Though the small samples used in these papers may indeed be representative of criminal directionality, it is difficult to make any claims of generalizability. Wiles and Costello (2000) is the first paper to investigate the travel patterns of offenders with a large sample of offenders, approximately 19,000. They find that offenders do have a directional bias towards urban areas, but there is no indication of the strength of that bias.

In this paper, we contribute to the directionality literature through an examination of directionality on a large number of offenders. We confirm a directional bias with this large data set and show the strength of the directional bias through computer simulation.

3. Data and methods

3.1. Data

All crime data are provided by the Royal Canadian Mounted Police in British Columbia. British Columbia is Canada’s western-most province, bordering the U.S. states of Alaska, Washington, Idaho, and Montana and the Canadian province of Alberta. British Columbia has approximately 4 million residents and a total of 186 police jurisdictions. The dominant police force in British Columbia is the Royal Canadian Mounted Police (RCMP), responsible for policing 174 of the 186 British Columbia police jurisdictions and 67 percent of the provincial population, approximately 2.7 million persons.3 Because of the variety of jurisdictions, the RCMP patrol urban, suburban, and rural areas. The incident-based data used in the analyses below are extracted from the RCMP Police Information Retrieval System (PIRS). All data are extracted from August 1, 2001 through July 31, 2006. The files contain for these five years the complete set of incidents dealt with by the RCMP. Within these files, there are details regarding the offence event, such as location and type of crime. Linked to the events are the people involved in the event, their role, and home address, amongst others.

The PIRS database contains information for approximately 5 million negative contacts with the police involving approximately 9 million individuals (offenders, victims, complainants, and witnesses) over the five available years. Despite the PIRS database being so large and there being 174 different police jurisdictions

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2 The second edition of their work, Rengert and Wasilchick (2000) performed the same analysis.

3 The remaining police jurisdictions include Abbotsford, Central Saanich, Delta, Esquimalt, Nelson, New Westminster, Oak Bay, Port Moody, Saanich, Vancouver, Victoria, and West Vancouver—Esquimalt merged with Victoria after our data time frame ended.
referred to as the 2622 offenders and 8126 burglaries for the entire province. This yielded repeat offenders who were charged or had charges recommended against them in at least 2 burglaries were analyzed. This yielded 2622 offenders and 8126 burglaries for the entire province. This dataset is hereafter referred to as the “real” dataset.

A breakdown of the percentages of offenders that had different numbers of crime trips is shown in Table 1. Immediately evident from this Table is that the vast majority of offenders had been charged with 2 or 3 burglaries. Though there are offenders with more than 10 crime trips, these offenders consist of 2.2 percent of the data. Therefore, their inclusion or exclusion has little qualitative impact on the results below.

For comparative purposes, a “baseline dataset” was generated through a simulation using randomized data for each offender’s home location and crime locations. This dataset consisted of 100,000 simulated offenders, each having a randomly generated XY coordinate for the home location. In this baseline dataset, each offender had c crimes associated to them, where c was randomly determined but was between 4 and 21. Finally, each crime had a randomly generated XY coordinate associated to it to determine the location of the event. Though it is possible for the location of the event to be placed in an unrealistic location such as in the middle of a lake or on top of a mountain, this is not problematic for the analysis at hand. This is because we are concerned with the direction the offenders move, not the location itself. In total, 1,000,000 simulated offence locations were generated.

Because our simulated baseline dataset was created randomly, we know that there is no directionality preference present. Therefore, if the results of the analysis on this baseline dataset are similar to the real dataset, it would imply that directionality preference does not exist in offender activity. However, if significant differences do exist, then we can conclude that actual offender activity does exhibit directionality preferences.

In addition to the data for all of British Columbia, we include the analysis of two municipalities within the Metro Vancouver region (Coquitlam and Surrey) and one municipality outside the Metro Vancouver region (Prince George)—the selection of these municipalities is primarily because they contain a large number of criminal incidents. Coquitlam is a city of approximately 115,000 persons, whereas Surrey is a city of approximately 400,000 persons and Prince George is a city of 71,000 persons. Aside from their size, these three municipalities each have very different urban forms.

Both municipalities within Metro Vancouver have urban sprawl, light industry, strip development and malls, apartments, and single family dwellings, but the locations of these facilities are quite different for each municipality. Coquitlam essentially has one commercial district centred on a large shopping area. The area also contains a major transportation hub, and direct train-line to downtown Vancouver, a library, a college campus and a sports complex. This commercial district not only attracts residents of Coquitlam, but residents from neighbouring municipalities because of its size. In contrast, Surrey has multiple commercial districts and regional shopping areas, each large enough to attract residents from neighbouring municipalities because of its size. In contrast, Surrey has multiple commercial districts and regional shopping areas, each large enough to attract residents from neighbouring municipalities as well. Of course, this is in part because of Surrey’s greater population. However, the importance of this comparison is to investigate the impact of urban form on directionality. Prince George is included to provide a more rural example of the importance of directionality. A priori, we expect that offender residents of Coquitlam will exhibit a stronger degree of directionality than their counterparts in Surrey and Prince George because there is essentially only one place to go in Coquitlam. In Surrey, offender residents may have just as strong a directionality preference if they consistently select one area for their criminal activities. However, with greater choice in targets we expect a weaker directionality preference, in the aggregate.

### 3.2. Measuring directionality

In order to measure the degree of directionality preference of an individual, all c crime locations of the individual are mapped. From...
these mapped locations an angle, called the Crime Activity Angle (CAA), is enclosed around the locations. In an effort to eliminate outliers from the analysis, a parameter \( p \) (where \( 0 < p < 100 \)) is used to denote the percentage of crimes that must be included in the CAA. The CAA is positioned such that the vertex of the CAA is centred on the home location and oriented such that the size of the angle is as small as possible, while still capturing \( p \) percent of the offences by that individual. The larger the value of \( p \), the larger the CAA has to be in order to accommodate the larger percentage of offence locations it needs to capture.

The smaller the angle that is created, the larger that the directionality preference exhibited by the individual. If there is no directionality preference and all crime locations are scattered equally around the home location, then the expected size of the CAA can be calculated mathematically using Eq. (1):

\[
\text{size of CAA} = \frac{360(pc - 1)}{c}
\]

For example, in order to enclose 50 percent of 20 crime locations that are randomly distributed, the expected size of the angle is 162°. However, if the crime locations are not randomly distributed and they show clustering, then the actual size of the CAA cannot be modelled as it will be smaller than the randomized model.

4. Results

In order to establish that there is directionality preference evident for offenders, the results for all of British Columbia are compared to the randomized model. Following this, two municipalities (Coquitlam and Surrey) within the Metro Vancouver and one outside of Vancouver (Prince George) are compared to see how the urban form impacts this directionality preference.

4.1. Is there directionality preference?

In order to measure the effect of directionality preference for the entire population of offenders, the \( p \) value was initially set to 50 percent, then the size of the CAA for each individual was computed. The cumulative number of offenders, from both datasets, who have a CAA less than an angle of specific size was then plotted (Fig. 2).

Evident from Fig. 2, the curves produced for the two datasets are different. For half the population a CAA size of 20° is required in order to capture 50 percent (\( p = 50 \)) of their crimes. If no directionality preference is present, as is the case for the randomized dataset, the size of the CAA turned out to be 40°. This is a difference of a factor of two. From another perspective, if there was no directionality preference, based on the randomized dataset, it would be expected that about 55 percent of the population have a CAA less than 45 percent; however, 78 percent of the population satisfy this constraint. This clearly indicates that there is a significant difference between the expected directionality preference for individuals, and what is seen in actual offender activity. Consequently, half of all criminal activity of those in the present sample is captured by a very small CAA. In fact, only 5.5 percent of the potential directions available to offenders are used by the offenders when committing crimes.

We then increased the \( p \) value to 75 percent in order for the CAA to enclose a greater portion of the crime locations. As shown in Fig. 3, for half the population, there is a difference of 31° between the expected and actual CAA sizes. For this same population, it is expected that 16 percent of the population has a CAA size of 45°. However, approximately 34 percent has that CAA size. Again, a notable difference between what was expected and what is manifest.

Lastly, Fig. 4 shows the results for \( p = 100 \), in order to consider all of the offenders’ crime locations. As expected, the CAA has increased substantially, but the same patterns remain: for half the population there is a difference of 30° between the expected and actual CAA sizes. And it is expected that 15 percent of the population has a CAA size of 45°, but approximately 29 percent have that CAA size.

Overall, these results are typical. Similar differences between actual and expected CAA sizes were found as the \( p \) value was varied between 50 and 100. Clearly, a strong directionality preference is present for offenders in this dataset as the two graphs were very distinct for all \( p \) values tested.

4.2. Variations in directionality preference

Turning to the results for the three individual municipalities (Coquitlam, Surrey, and Prince George), the results are notably...
5. Discussion and conclusion

Directionality matters. This claim has been easy to justify from a theoretical standpoint for this element of spatial criminology, but has largely evaded empirical verification. Though, as noted above, a small number of studies have investigated the importance of directionality. However, these studies have either been based on small samples or little detail is garnered from the data.

This paper is the first analysis of the strength of directionality in offending based on a large incident-based dataset and varying urban forms. Through the use of a simulation of randomized data, we are able to quantify the magnitude of directionality preference for repeat offenders in British Columbia, Canada. We find a significant difference between the randomized data and actual criminal activity. We also find significant differences in the strength of directionality preference within different urban forms. Therefore, when considering spatial decision-making for crime, directionality must be given as much consideration as place and distance if we are to understand the spatiality of criminal incidents.

Place has been clearly shown to matter for predicting actual crime locations. Whether an analysis considers place attributes such as hot spots, routine activity nodes, or the pathways between them we know that crime is neither randomly nor uniformly distributed across space. We also know that offenders, on average, commit their crimes close to home, especially violent crimes. With regard to distance, understanding directionality may be used to identify suspects: not only is the offender likely to live “close by”, but also from a particular direction. This potentially allows investigators to use their local knowledge of the built environment to predict where the offender came from. In the context of place, directionality may also be used to identify the establishment of developing crime generators and crime attractors (Brantingham & Brantingham, 1995). If the directional bias of offenders is monitored, places that are developing as crime generators and crime attractors may become the targets of crime prevention initiatives to prevent these places from becoming hot spots. Such crime prevention initiatives are classified as “secondary” according to the primary-secondary-tertiary (PST) model of crime prevention (Brantingham & Faust, 1976) because they identify and intervene at places before they become a problem.

As with any analysis, ours has its limitations. First and foremost, our analysis is based on police data. Though, because of the nature of the crime, burglary has a high reporting rate to the police, it also has a low clearance rate—approximately 8–9 percent over our study period with little variation year to year. Consequently, our data contain a small fraction of the actual number of burglars. We must assume they are representative. Second, as briefly discussed above, we must assume that the journey to crime begins from the home. This common assumption is made because we only have geographic data for the crime locations and the home addresses of the burglars. Last, we are only able to identify a directional bias with regard to the journey to crime. This is not problematic, but limits our ability to further inform theory. Both the geometric theory of crime (Brantingham & Brantingham, 1981, 1984, 1993) and temporal constraint theory (Ratcliffe, 2006) predict a directional bias that is rooted in peoples’ awareness space, more generally, not just the journey to crime.

Now that we have shown empirically what we have known theoretically for decades, there are a number of implications and future research directions. First, both individual and collective directionality may be used in geographic profiling (Rossmo, 2000) to further narrow down suspects, not just proximity. Second, if multiple offenders move towards the same location, crime prevention through environmental design (CPTED) methods may be better focused. And third, knowledge of offender residences and relevant directions may be applied to explaining and predicting where crime is higher.

With regard to future research, a number of issues are immediately apparent. First, does the strength of directionality vary with

![Fig. 4. CAA of individual versus size of angle, p = 100.](image-url)
crime type? Similar to the element of distance, we should not expect directionality to be the same for all crime types. Second, where/what are offenders attracted to? The distribution of opportunities will certainly influence direction of travel. All offenders in a relatively large area may be attracted to one location such as a shopping mall (global convergence), or offender attractors may vary across relatively small areas (local convergence). Thirdly, how many “directions” do offenders use? The geometric theory of crime posits multiple nodes. If a significant portion of offenders only have one direction and there is a pattern to that direction (most often towards a drug dealer, for example), this information may be useful for investigative purposes. Is directionality preference related to the prolific nature of repeat offenders? In other words, do repeat offenders become more or less directionally biased as their number of offences increases? There is also the question of directionality for co-offending. The common meeting grounds probably have the major orientation for the direction of travel. Research on wayfinding supports increased directionality in well-known areas. With offenders returning to their original targets or near them as criminality of place and with crime attractiveness, it is possible that directionality is more pronounced with clustering of criminal events. Understanding the street structure, the mode of movement (pedestrian, public transit, by motor vehicle) will likely influence the directionality/distance interaction.

Needless to say, in our confirmation of a directionality preference using a large incident-based data set, we pose more questions than we answer. However, it should be clear that direction is an important aspect when considering the spatial dimension of criminal activity.

References