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The geography of crime and crime control

1. Geography of crime

Scientific interest in the geography of crime is not new. The large variation in crime across space and time is one of the oldest puzzles in the social sciences (Glaeser, Sacerdote, & Scheinkman, 1996). In fact, the study of crime started with questions about its geography. Already in the 19th century, Guerry (1833) and Quetelet (1842) published maps of personal and property crime in France, while Mayhew (1862) mapped London's rookeries, a colloquial term used for slum areas. During the first decades of the 20th century, scholars of the Chicago School of Sociology developed an ecological model of urban geography, including the concentric zone model (Park, Burgess, McKenzie, & Wirth, 1925) and an application to juvenile delinquency (Shaw & McKay, 1942), that remained a theoretical and empirical blueprint for many decades. During the 1980s, after a long period of relatively modest progress, the advent of opportunity-based crime theories, the digitalization of law enforcement data and crime records, and the availability of computerized geographic information systems (Chainey & Ratcliffe, 2005; Weisburd & McEwen, 1998) gave a new impetus to the geography of crime. Today, crime is regularly and increasingly covered in research articles appearing in Applied Geography (e.g., Barnum, Caplan, Kennedy, & Piza, 2017; Sadler, Pizarro, Turchan, Gasteyer, & McGarrell, 2017; Summers & Caballero, 2017) and in other geography journals as well. While the possibilities and versatility of geospatial analyses of crime have convincingly been demonstrated to criminologists and geographers alike, recent technological advancements call for a reappraisal of established insights in the role of place in crime. Consider, for example, the prospects offered by the availability of online mapping and navigation applications for the study of crime and place (Vandeviver, 2014). Similarly, the proliferation of smartphones (Hoeben, Bernasco, Weerman, Pauwels, & van Halem, 2014) and the adoption of location-tracking technologies (Versichele, Neutens, Delafontaine, & Van de Weghe, 2012) offer new possibilities to study offenders' and victims' spatial behavior. Many of these developments are addressed in the contributions to this special issue of Applied Geography.

2. Theoretical frameworks

While crime maps are the most visible aspects of the geography of crime, the explanation of spatial patterns and its application in addressing crime problems, require a theoretical framework. Grounded in the ecological approach of the Chicago School, the geography of crime has long been based on social disorganization theory, which links the occurrence of crime to characteristics of residential communities and their residents. Contemporary studies are increasingly based on opportunity-based theories. These theories highlight the spatial dimension of crime and reactions to crime by illustrating the role of the social and physical environment in the commission of crime and the selection of crime targets. In doing so, these theories provide a rationale for the importance of place in our understanding of crime and offer opportunities for the development of place-based crime prevention policies (Eck & Weisburd, 1995). The opportunity theories of crime include the rational choice perspective, the routine activities theory and crime pattern theory. Because elements of each of these theories are present in nearly all research on the geography of crime and crime control, we briefly summarize these theories here.

The rational choice perspective on crime and crime control (Cornish & Clarke, 2008, 1986) focuses on offender decision-making. It argues that offending is purposive behavior through which offenders seek to benefit themselves. In their decision to offend as well as their selection of a crime site, offenders balance the costs and benefits of their choices and select that option through which they expect to achieve the greatest benefit for themselves. As such, this perspective highlights that crime does not occur at indiscriminate locations but that crime site selection is the result of a (semi-)conscious decision-making process. This perspective emphasizes that offenders' spatial decision-making process is informed by a range of attributes of the physical and social environment.

The routine activities theory (Cohen & Felson, 1979) stresses that for a crime to occur a motivated offender and suitable target must converge in space and time in the absence of capable guardians. Targets can be persons or objects. The amount of crime at specific places can fluctuate due to changes in the number of motivated offenders, available targets or capable guardians. Through changes in their spatial behavior, offenders may seek to create suitable opportunities for crime. Routine activities theory thus emphasizes the importance of situational characteristics of places in the commission of crime.

Crime pattern theory (Brantingham & Brantingham, 1984, 2008) combines elements from the rational choice perspective, routine activities theory and environmental psychology, to explain variation in the spatiotemporal distribution of crime. Crime pattern theory states that rational offenders become aware of suitable targets in the absence of capable guardians while performing their daily activities and routines. Offenders may exploit these opportunities immediately or return to exploit them later. Crime, then, is the result of the interactions between motivated offenders and their physical and social environment.

3. Two stylized facts

Parallel with the development of the opportunity theories of crime, police recorded crime data were increasingly digitalized and academics harnessed the growing power and versatility of

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computerized geographic information systems to increase their understanding of the spatial distribution of crime and offenders' spatial behavior (Weisburd, 2004). These developments have facilitated empirical research about a wide variety of topics on the geography of crime. Here, we want to put the spotlight on two major stylized facts that have been corroborated over and again: (1) the strong concentration of crime at micro-places, and (2) distance decay in the journey to crime.

3.1. Crime concentration at micro-places

First, crime is not equally nor randomly distributed in space. In fact, crime is strongly concentrated in just a few places of high-crime intensity. In analogy to geology, these high-crime intensity places are called hotspots of crime. For example, in their seminal work Sherman, Gartin, and Buerger (1989) established that just 3.5% of all Minneapolis' addresses produced 50% of all calls for service to the police. Similar results were observed in a variety of cities worldwide (e.g., Andresen & Malleson, 2011; Steenbeek & Weisburd, 2015; Weisburd, Maher, & Sherman, 1992), prompting Weisburd (2015) to formulate a law of crime concentration at places. This law states that "*for a defined measure of crime at a specific microgeographic unit, the concentration of crime will fall within a narrow bandwidth of percentages for a defined cumulative percentage of crime*" (Weisburd, 2015, p. 133). Scholars also determined that the degree of crime concentration at places is stable over time. Over a 14-year period, Weisburd, Bushway, Lum, and Yang (2004) concluded that half of all crime is concentrated in 4.5% of Seattle street segments. Furthermore, Weisburd et al. (2004) identified a small group of consistently high-crime street segments (see also Andresen, Linning, & Malleson, 2016; Curman, Andresen, & Brantingham, 2015; Wheeler, Worden, & McLean, 2016). The location of crime hotspots, however, may change and existing high-crime intensity places may become cold one year while new places emerge as hot another year (Hodgkinson, Andresen, & Farrell, 2016).

3.2. Distance decay

Second, when tracking offenders' spatial behavior associated with their offending and crime site selection scholars found that offenders typically travel only short distances to offend (Bernasco, 2014; Birks, Townsley, & Stewart, 2012; Rengert, 2004). For example, Wiles and Costello (2000) established that the average travelled distance to a crime site across all crime types for Sheffield offenders was just over 3 km. While some offenders are prepared to travel longer distances to offend (Polisenska, 2008; Van Daele, Vander Beken, & Bruinsma, 2012; Vandeviver, Van Daele, & Vander Beken, 2015), short crime trip distances have repeatedly been observed in a large number of studies for a variety of crimes and have come to be accepted as typical offending behavior (e.g., Barker, 2000; Beauregard, Proulx, & Rossmo, 2005; Capone & Nichols, 1975; Lundrigan & Czarnomski, 2006; Rattner & Portnov, 2007; Smith, Bond, & Townsley, 2009). A closely related observation is that the likelihood of a particular location being selected decreases dramatically as the distance from the offender's home increases (Rengert, Piquero, & Jones, 1999). This is known as the distance-decay effect. It is not unique to offending behavior but governs most human spatial interactions (Taylor, 1983). Distance decay in offenders' spatial behavior has repeatedly been observed in studies focusing on the distance that offenders travel prior to committing their offences, so-called distance-to-crime studies (e.g., Block & Bernasco, 2009; Rengert et al., 1999; Van Koppen & Jansen, 1998; Vandeviver, Van Daele, et al., 2015), as well as crime location choice studies, which explore how offenders select a target and what target characteristics influence offenders' spatial decisions (e.g., Baudains, Braithwaite, & Johnson, 2013; Bernasco & Nieuwbeerta, 2005; Johnson & Summers, 2015; Townsley et al., 2015; Vandeviver, Neutens, Van Daele, Geurts, & Vander Beken, 2015). The presence of distance decay in offenders' spatial interactions has frequently been interpreted as evidence of offender strategies to minimize the costs associated with overcoming distance (Bernasco, 2014; Vandeviver, Van Daele, et al., 2015).

4. Applications to policing

Law enforcement agencies noticed the importance of the spatial dimension of crime as well. In searching for efficient and cost-effective crime control strategies, since the 1980s police forces have embraced the renewed interest in the spatial dimension of crime, and have successfully implemented a series of place-based crime prevention and control initiatives (Weisburd, 2004). This should not come as a surprise. Police and crime prevention resources are scarce and should be used as cost-effectively as possible. Given that the bulk of crime is generated at a handful of small high-crime intensity places, and that place has a higher predictive value for future crime than offender identity (Sherman, 1995, pp. 36–37), it makes sense to prioritize law enforcement deployment to those places that need it the most and where the chances of reducing crime and improving citizens' quality of life are the highest (Braga, Papachristos, & Hureau, 2014). Similarly, police investigations could be more cost-effective and possibly more successful in identifying offenders by adjusting and prioritizing investigative efforts based on offenders' spatial behavior (Rossmo, 2000).

4.1. Hotspots policing

Hotspots policing proved to be one particularly successful and effective place-based crime control strategy (Braga et al., 2014). Hotspots policing is informed by opportunity-based crime theories and based on the observation that crime is highly concentrated in a small number of places. While onsite police tactics may differ, the essence of hotspots policing entails directing patrols to a small number of predefined high-crime areas (Braga et al., 1999; Sherman & Weisburd, 1995). Crime hotspots are identified through mapping crime and analyzing the spatial distribution of offences. The rationale underlying this policing strategy is that by dramatically increasing visible police presence at high-crime locations, offenders will be deterred from committing offences at these locations and the local crime and disorder level will drop. The effectiveness of hotspots policing for reducing crime at such locations has garnered strong empirical support (Braga et al., 2014; Bureau of Justice Assistance, 2013). Hotspots policing has been found to substantially reduce crime at high-crime locations and locations immediately around crime hotspots (Braga et al., 1999; Sherman & Weisburd, 1995) and may also have a benign spillover effect by reducing crime in the larger environment in which such policing strategies are implemented (see Weisburd, Braga, Groff, & Wooditch, 2017), a phenomenon labeled 'diffusion of benefits'.

4.2. Predictive policing

Given the success of hotspots policing, researchers have explored the possibility to predict where and when future high-crime locations are likely to develop and intervene at those locations before they have become proper crime hotspots. This resulted in prospective hotspots policing (Bowers, Johnson, & Pease, 2004) and the development of spatiotemporal crime forecasting models (Johnson, Bowers, Birks, & Pease, 2009; Mohler, Short,

Brantingham, Schoenberg, & Tita, 2011). Both approaches are firmly rooted in the geospatial analysis of crime and draw on principles and techniques from spatial epidemiology and earthquake aftershock models from seismology. They take advantage of the spatiotemporal clustering of crime and the predictive power of prior victimization for future victimization (Johnson & Bowers, 2004). Underpinning both approaches is the observation that an offence occurring at a particular location flags an increased likelihood of repeat victimization of that location in the near future (repeat victimization) and of locations in close proximity to it (near repeat victimization) (Townsley, Homel, & Chaseling, 2000, 2003). Instead of targeting existing crime hotspots, prospective hotspots policing approaches seek to identify where future hotspots are likely to emerge based on recent spatial offending patterns. To be implemented effectively, they require geospatial analysis of recorded crime data to be conducted on very short notice, preferably in real time. Once identified, police presence at those locations can proactively be increased to reduce or even completely eliminate the risk of those locations developing into high-crime clusters. Similarly, crime forecasting models seek to predict where and when individual crimes are likely to occur. By pinpointing in near real time those places where crime is likely to occur, police forces can deploy their personnel with even greater precision and possibly more effect (Mohler et al., 2015).

4.3. Geographic profiling

Research on the spatial dimension of crime not only informs crime prevention and crime control strategies, but also informs criminal investigations. Geographic profiling is an investigative technique that is based on the analysis of offenders' spatial behavior (Canter, Coffey, Huntley, & Missen, 2000; Rossmo, 2000). Its goal is to prioritize investigative activities of law enforcement agencies to a geographically limited search area in which a serial offender is likely to live, or have a major anchor point (such as their workplace or school). To predict the offender's most likely anchor point and define a search area, the technique inverts the logic underlying the distance-decay phenomenon in offending behavior. The observation that offenders commit their offences not far from their home is essential to this approach. The input to geographic offender profiling is a series of locations of offences committed by the same unknown offender, but can be further extended by including additional spatial information such as geodemographic data, bar locations, schools and established crime hotspots (Rossmo, Davies, & Patrick, 2004). The approach is now routinely used by various law enforcement agencies worldwide, in particular in investigations of serial offenders committing serious crimes like murder, rape, armed robbery or arson (Rossmo, 2012).

5. Future challenges and opportunities

Without any doubt, in the near future the geography of crime and crime control will be enriched with new research questions and new techniques will become available to answer existing questions. With the risk of being proven wrong very soon, we sketch some likely directions here. We anticipate that change will be mostly driven by technological developments.

Within less than a decade, the internet and other developments in information and communication technology will have changed crime and law enforcement considerably, if only because the volume of reported online crimes and cybercrimes has skyrocketed and because many types of offline crime have become supported by online information or tools (Wall, 2007). Online crimes transcend geographic limitations, because they do not require victims and offenders or offenders and co-offenders to be in close physical proximity, and for crimes to be committed offenders do not even need to know where their victims or co-offenders are located. There is some evidence, however, that correlates of geographic proximity, including social networks, language and other cultural similarities, continue to play an important role in the commission of cybercrime and online crime. As a result, geographic proximity also shapes the relations and interactions between cybercriminals, their victims and their co-offenders (Leukfeldt, Kleemans, & Stol, 2017). For a general and comprehensive discussion about the relations between space, place and information technology, see Graham (1998).

The development of mobile information and communication technologies will transform the geography of crime for three different reasons: (1) offenders use new technologies when committing crime, (2) law enforcement rely on new technologies to prevent and investigate crime, and (3) researchers use new technologies to study crime.

Like all technology, information and communication technology can be used for illegitimate purposes. As an obvious example, think of how mobile phones could assist a group of juveniles in communicating about their committing a burglary or stealing an item from a shop. Also consider the amount of information, including location information, that is available online about businesses and individuals in social media, and how it could make those to whom it pertains vulnerable to criminal victimization. A recent study (Stottelaar, Senden, & Montoya, 2014) demonstrated that runners sharing their routes via online sports tracking networks inadvertently disclose their home address. By sharing their address and their running times, they might provide prospective residential burglars a suitable target and opportunity for crime, although the study did not investigate whether burglars actually search and use such information. In a popular account Goodman (2015) paints an alarming picture of the potential criminal uses of emergent technologies. Interestingly, many of the identified dangers are related to location and mobility (e.g., using drones or self-driving cars). In the arms race between criminals and law enforcement, police and other law enforcement agencies have to keep up with criminals and use many of the same new technologies in the prevention, detection and investigation of crime (Ekblom, 1997, 1999).

Recent technological developments will not only inform criminals and law enforcement agencies, but will also allow researchers to refine their understanding of the geography of crime, and to study it from new angles and perspectives with even greater detail. For example, the availability of online navigation and mapping applications may open up new approaches to studying the crime-place nexus and make detailed micro-level spatial data available for research (Vandeviver, 2014). Smartphones and persistently collected location data have great potential as new sources for detailed spatiotemporal data on their users' spatial behavior which can be linked to geographic aspects of victimization and offending (Hoeben et al., 2014). The availability of such data may equally create opportunities to study the journey to crime (for an interesting explorative study that tracked journeys to crime, see Rossmo, Lu, & Fang, 2012) or even the journey to victimization in unprecedented spatial and temporal detail (Wiebe et al., 2016). In the same vein, increasingly implemented technologies such as gunshot detection systems and visitor-flow tracking technology (Versichele et al., 2012) could impact place-based crime control strategies. These technologies could allow law enforcement agencies to detect criminal incidents as they unfold in real time in the urban environment and adjust policing strategies on the fly. However, much less is known about the spatial dimension of reactions to crime and crime's impact on citizens. Spatial analysis acknowledging that not all crimes have an equally great impact on victims and society would be one avenue to explore in the recent

future. Another avenue could be to pursue a better understanding of the physical and social environment's impact on fear of crime and citizens' worry of victimization. Finally, despite a few initial attempts to GPS-track ranger patrols in the prevention of wildlife crime (Lemieux et al., 2014; Moreto et al., 2014) and police patrols in the prevention of urban crime (Davies & Bowers, 2015), one practically untouched research subject remains the spatial dimension of crime control as such. Questions surrounding the spatial behavior of law enforcement officers, their spatial decision-making processes and how attributes of the physical and social environment impact the outcome of this process remain mostly unanswered to date.

6. Contents of the special issue

In the opening article, Weinborn and colleagues make a case for considering the severity of offences when studying the spatial distribution of crime. In a series of spatial analyses, they compare crime concentration and crime harm concentration. Both crime and harm are highly concentrated in a handful of street segments but harm is three times more concentrated in space than crime.

Building on the crime harm framework, Curtis-Ham and Walton seek to establish if New Zealand neighborhoods most vulnerable to crime are also those suffering most crime harm. They compare New Zealand Police's current approach of identifying the most socially disadvantaged and high-crime neighborhoods with a newly developed crime harm index. They find that spatial patterns of crime vulnerability and crime harm differ and that neighborhoods most vulnerable to crime are not necessarily those suffering high crime harm levels.

Hardyns, Rummens and Pauwels investigate the potential of predictive policing for home burglary, street robbery, and battery. Their analysis uses a fine-grained spatial grid, and distinguishes between daytime and nighttime predictions. Based on various success criteria, they conclude that predictive policing appears a promising technique, and that including the daytime-nighttime difference leads to significantly better predictions.

In their contribution, Irvin-Erickson and colleagues evaluate the sensitivity of Gunshot Detection Technology (GDT) relative to calls for service in Washington, DC. Using temporal comparisons for month, day of year, weekday, and hour of the day, they find that the relative sensitivity of GDT was much stronger in the evening and at nighttime than in the daytime, and that it decreased with distance from the nearest zone centroid. They conclude that the technology has the potential to improve data collection on gun use and gun violence and, thereby, improve police operations and public support for police.

Griffiths, Johnson and Chetty use mobile phone data to study the spatial behavior of four UK terrorist plot ringleaders in the months prior to their attacks. Terrorists' spatial behavior is found to exhibit regularity. Terrorists' activities were spatially clustered around a handful of locations and, in line with the distance decay principle, most movements were close to homes or safe houses. Mixed findings are reported with regard to changes in the regularity of terrorists' spatial activities as the time of the attack approached.

Using observational data on 1551 houses, Peeters and Vander Beken explore the effects of environmental characteristics derived from the Crime Prevention Through Environmental Design (CPTED) framework on the risk of residential burglary. They conclude that the risk of residential burglary in and near the city center is related to characteristics of access control, while elsewhere the risk is related to characteristics of surveillance.

Langton and Steenbeek combine police-recorded burglary addresses with observational data of these same addresses collected through Google Street View to investigate the influence of physical attributes of residential homes and their immediate surroundings on residential burglary risk. They find that ease of escape from a property, property accessibility and property surveillability increase burglary risk. Indicators of wealth, however, were not related to burglary risk.

In the final article, Chataway and colleagues explore the feasibility of mobile phone technology and location-triggered ecological momentary assessments (EMAs) to collect meaningful context-dependent data on fear of crime and risk perception. The data produced by this approach exhibit high degrees of internal consistency and reliability and support most hypothesized associations between concepts in contemporary fear of crime models. However, the low number of completed and returned EMAs prohibited the researchers from conducting place-based analysis. This was compounded by the difficulty of grouping participants to identify one unique place due to spatial and temporal variability between respondents who completed and returned EMAs. Chataway and colleagues discuss possible strategies to address this limitation in future research.

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