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Section "Predictive Models and Geographic Profiling"

Goodwill, A.M., Kemp, J.J. van der & Winter, J.M. (2013). Applied Geographical Profiling. In G.J.N. Bruinsma & D.L. Weisburd (Eds.), Encyclopedia of Criminology and Criminal Justice (pp. 86-99). New York: Springer.

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TITLE: Applied Geographical Profiling

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SYNONYMS: Geographical Offender Profiling; Geo-forensic Analysis; Journey to Crime;

1.0 Overview

Geographical offender profiling (GP) is the practical application of various geographical, criminological and psychological principles to typically estimate the most likely area of an offender's home base (e.g., the offender's residence) or anchor point (e.g., place of work or frequent activity) based on the location of their criminal activity (e.g., crime sites) (Rossmo, 2000). The output of a GP analysis can inform ongoing investigative strategy in several ways (Rossmo, 2000): suspect prioritization, patrol saturation, neighborhood canvasses, police information systems, and DNA searches to name but a few (for further strategies used, see Knabe-Nicol & Alison, 2011). This chapter aims to introduce the reader to the environmental criminological and psychological basis of geographical profiling, discuss state-of-the art journey to crime (JTC) research, and advocate the further integration of routine activity theory into a geographical offender profiling framework.

Although GP is not firmly grounded in empirically tested theories (Levine, 2005), it does utilise several theoretical approaches from the broader framework of environmental criminology: namely *Crime Pattern Theory* (Brantingham & Brantingham, 1984), the *Routine Activity Approach* (Cohen & Felson, 1979), and the *Rational Choice Perspective* (Cornish & Clarke, 1986). A number of researchers have (partially) borrowed from these three theories to develop mathematical and computerised models to (typically) predict the location of an offender's home (see Canter & Youngs, 2008a, for review). However, to date very few studies (see section 3.3 for a review) have tested theories and/or provided empirical explanations integrating the routine activity of offenders or the socio-geographical features of the areas surrounding crime locations (e.g., topography, transportation routes, social nodes, etc.).

It is perhaps an obvious fact that to commit an offence an offender must, in all but the rarest of cases, be at least for some time period in the area of the crime location. Even so, an offender may still live far away from that area and/or they may only be in that area for a short period of time. Nevertheless, the offender *must* be in that area at some point and thus the area *must* form part of geographic area they (now) know of – their *activity* space. Further, several researchers (e.g., Canter & Larkin, 1993) have suggested that offenders, just like any other individual, will *routinely* visit the same areas (e.g., activity space) and are less likely to venture into unknown areas of equal opportunities). This suggests that offenders not only have areas of *activity* but also areas of *routine activity* – places or area they routinely travel to or through. According to routine activity theory (discussed in detail in section 2.2 below) crimes (and their associated geographical locations) occur during this routine, normal activity of everyday life. As such, offence locations may give insight into

that particular offender's *routine activity* – which may give rise to their identification (Canter & Gregory, 1994).

Thus, it is vitally important to know who is routinely using the area in which a crime is committed and for what reason because the offender will theoretically be among this, albeit potentially large, list of individuals. In spite of this, the majority of GP approaches and computerised systems do not prioritise lists of people known to use the area around a crime location but instead typically prioritise areas to investigate, which in turn, may generate a list of actual suspects. However, even in cases where a GP prediction of an area is so precise that it pinpoints a single dwelling (e.g., a GPS coordinate or prioritised area), the *identity* of the offender is still not predicted, only that that dwelling is the area most 'associated' with the crime locations (e.g., may indicate a psychological anchor point or place of importance to the offender, such as their home). Arguably, this can still be vitally important to an investigation if accurate, but ultimately, incorporating information on who (e.g., individual identities) routinely use that space (amongst other types of information) may elicit a more encompassing comprehensive view of the area around a crime location and even identify the actual perpetrator.

In the latter half of this chapter the current authors call for a greater integration of routine activity theory in GP research and theory, highlighting the current practices of geo-profilers and future directions of geographical profiling. However, first the underlying theoretical aspects of GP, the state-of-the-art research in JTC analyses and the prominent debates within the literature will be highlighted. Our aim is to state the importance of moving away from a largely mathematical and computational approach focused on predicting an offender's home base (or anchor points) using *only* x/y coordinates to a more substantive and comprehensive psychological sociological and criminological GP model.

2.0 Describing Offender Movements: Environmental Criminological Theory

There has been a long history of describing the geographical or spatial movements of offenders (see Canter & Youngs, 2008b for review). Research has developed largely from a criminological perspective, describing the movement in relation to differences in offender characteristics, victim types, and cultures and most commonly in relation to sex offending (e.g., Rossmo, 2009, for review). The basis of the environmental criminological perspective will now be discussed.

2.1 Crime Pattern Theory & Awareness Space

In their seminal *Crime pattern theory,* Brantingham and Brantingham (1984) consider how offenders move about in time and space. Building on the work of urban planners, they suggest that the spatial occurrence of crimes is not random, but directly related to the immediate physical and environmental circumstances. Brantingham and Brantingham (1984) propose that offending has a rational basis as offenders move predominantly within familiar spaces in which they identify potential targets. Therefore each person's own *activity* space is confined by their *awareness* space, which is reflected in each individual's own '*mental map'*. The latter is a unique cognitive representation that explains and defines each individual's *awareness* space, where the *activity* space represents the *habitual* area that the offender uses for the majority of his non-criminal activity. However, the non-uniform distribution of targets (e.g., victims), causes criminals to offend in a subset of their *awareness* space, termed the *opportunity* space. *Activity* space and *opportunity* space will most likely overlap completely (Brantingham & Brantingham, 1984). Hence, the *opportunity* space (e.g., criminal area) of an offender can also reveal the non-criminal *activity* space (e.g., routine activity space) of the same individual.

2.2 Routine Activity Approach

Routine Activities Approach posits that offender and victims (or targets) usually meet during daily, non-criminal activities or routines (Cohen & Felson, 1979). In other words, crime originates in the context of the normal everyday routines as three spatiotemporal factors converge: a *motivated offender*, a victim or *potential target* and the *absence of a capable guardian* (Cohen & Felson, 1979). This is important for practical purposes since it suggests that offences committed in a rather spontaneous fashion are likely to be in an area familiar or habitual to the offender. Thus, it may be hypothesised that a rapist that attacked his victim in an impulsive or opportunistic way, was in the area for non-criminal reasons (e.g., on his way home from his local bar). In other words, the area is likely a part of the offender's routine activity space and, as will be discussed in later sections of this chapter, there is possible information (e.g., eyewitness, archival records, parking tickets, etc.) relating this particular offender to that particular activity space, potentially leading to his identification.

2.3 Rational Choice Perspective

The *rational choice perspective* suggests that crime is committed in terms of a multi-level, goal oriented, purposeful and crime specific decision-making process, especially concerned with the analysis of costs versus benefits within a constrained situation (Cornish & Clarke, 1986). However, determining the proportion of offenders using an implicitly unconscious cognitive or consciously reasoned cost-benefit analysis to commit crime is difficult. On the other hand, the concept of 'satisficing' could account for a rather intuitive approach of offender decision-making (Canter & Shalev, 2000). *Satisficing*, derived from 'satisfy' and 'suffice', refers to the acquirement of just enough information to make an acceptable but non-optimal decision. This is also supported by recent research investigating the heuristics burglars use to determine whether or not a house is occupied (Snook, Dhami & Kavanagh, 2010). Regardless of the underlying decision process, Cohen & Felson (1979) propose that the Rational Choice Perspective better accounts for the *content* of the decisions, while Routine Activities Approach better accounts for *why* decisions are made.

2.4 Theory Summation

These three general environmental criminological theories converge in the following way: Offenders are relatively more compelled to commit an offence (than not) if the situation is attractive (*Routine Activity Approach*), if it occurs in a familiar environment (*Crime Pattern Theory*) and yields a desired reward (*Rational Choice Perspective*). Such an environmental criminology perspective emphasises the complex interplay of the offender motivation, situational factors, geographical location and the victim or target in the genesis of a criminal event.

3.0 Geographical Offender Profiling (GP) Theory

In order to understand, and ultimately predict, the geographical mobility of offenders one must take certain psychological principles into consideration, hence the emergence of the application of psychological principles to geo- and environmental criminology, namely *geographical offender profiling*.

3.1 The Circle Hypothesis, Commuters and Marauders

It has been postulated that an offender's home is a psychological anchor point that influences their geo-spatial movements and criminal activity (Canter, Coffey, Huntley & Missen, 2000; Gabor & Gottheil, 1984; Rossmo, 2000). In fact, over 80% of the homes of serial rapists (Canter

& Larkin, 1993) and arsonists (Kocsis & Irwin, 1997) were located in the centre of a circle whose diameter was defined by the two most distant crime locations in their series.

This phenomenon, now known as the 'Circle Hypothesis' (Canter & Larkin, 1993), led to the bifurcation of offenders into, *marauders* and *commuters*. The former live somewhere within the area circumscribed by their offences, with their home-base as the nexus of their criminal activity (e.g., they offend outwardly from the centre of the circle). Conversely, commuters live outside the circle, which may be due to more optimal offending opportunities elsewhere from the area around their home. However, the ratio of marauders to commuters found initially, roughly 80% to 20% respectively, has not been consistently observed. For instance, looking at international studies, the percentage of serial raping marauders varies from 60% and 71% in Germany (Janke & Henningsen, 1995 in Mokros & Schinke, 2006 and Snook et al., 2005, respectively), 71% and 93% in Australia (Kocsis & Irwin, 1997 and Meaney, 2004, respectively). While research into serial property offenders has found an approximately 50/50 split between commuters and marauders (van der Kemp, Pulinckx & van Beijsterveldt, 2005).

Even considering a liberal proportion of commuters (20%), one in five offenders typically live outside the area circumscribed by their offences, making any GP predictions of where the offender lives based on the circle hypothesis alone inherently flawed. Therefore, before embarking on GP analysis, Rossmo (2000) suggests that it is imperative that the geo-profiler establishes whether the offender is a commuter or marauder (or '*poacher*' or '*local hunter*' in Rossmo terms, respectively). Although Rossmo does not elucidate on how this distinction is to be accomplished (van der Kemp, Pulinckx & van Beijsterveldt, 2005), some researchers have suggested a framework to predict whether an offender is a commuter or marauder (Meaney, 2004), albeit with limited success (Paulsen, 2007).

Thus, it seems that although utilising the circle-hypothesis principle to predict the home location of an offender is unlikely to be *enough* to produce accurate results in all cases, it is not without its theoretical wisdom. Conceptually, the circumscribed area is identical to that of Brantingham and Brantingham's (1984) criminal space, a subset of the offenders overall routine activity space. Therefore, the circle hypothesis may be a useful 'rule-of-thumb' to begin conceptualising the routine activity space of the unknown offender – the area the offender may commonly frequent in their everyday normal life as well. Accordingly, one can begin to investigate what features that space has, how that space was used in the criminal activity and importantly why the offender chose that particular space in relation to their criminal activity. A careful examination of

the nature of the space and its relationship to the routine activity space of the individuals within it may help to develop a richer geo-profile of the crime or crime series. In a routine activities approach to GP, what topographic features, transport routes, socio-geographical aspects, etc., of that area are likely influencing the offender and how does that inform predictions or prioritisation of the offender?

3.2 Geo-spatial Decision Making: Distance-Decay Theory

The *least-effort principle* (Zipf, 1950) offers a very plausible explanation of an offender's decision making process in selecting criminal activity targets by postulating that an individual faced with alternatives will most likely choose the easiest course of action. This appears to be supported by a wealth of research on *distance-decay theory* (e.g., Snook, Taylor, & Bennell, 2004) which states that the probability of offending decreases with increasing distance from the offender's home. The generalizability of distance-decay as a function of various types of crimes and individual offenders has been both supported (Rengert, Piquero & Jones, 1999) and contested (Townsley & Sidebottom, 2010; Van Koppen & De Keijser, 1997). For example, first Van Koppen and De Keijser (1997) and later Townsley and Sidebottom (2010) demonstrated that the phenomenon of distance-decay may be due to the *aggregation* of the individual variations in distances travelled by offenders, not by the individual distances themselves. However, a recent study by Bichler, Christie-Merrall and Sechrest (2011) supports the robust findings of distance-decay advocated by Rengert et al. (1999) suggesting that the *ecological fallacy* argument in distance-decay research is perhaps unwarranted.

Nevertheless, on an individual level the Least-effort principle, Routine Activity Approach and Rational Choice Perspective offer explanations of offender movements and geographically-related offending decisions. Pragmatically, it takes time, resources and effort to overcome distance. Thus, close targets and locations – especially those involved in daily routines – are preferable to those further away if the subjective benefit remains the same. Additionally, it is more challenging to function effectively in an environment one knows little about which makes familiar areas more attractive (Bernasco, 2007). The inherent non-uniformity in target (or area) attractiveness and familiarity in offenders' routine activity spaces offers rational choices to be made – *if (or when) I offend where should I do it* and *how close is too close to home*?

Accordingly, distance-decay is thought to be modified by two additional rational choice perspectives; *specialist selectivity* and *buffer zones*. Pettiway (1982) found that specialist selectivity is best reflected in the amount of effort that an offender puts into planning and selecting a crime. Criminals that were more specialised and selective in their choice of targets did not follow normal

distance-decay patterns, but offended further away from home. This appears to apply inter-relatedly across crime types as well, with the more impulsive crime of rape occurring closer to home than carefully planned armed robberies (Pyle, 1974). Furthermore, the risk to the offender of being identified may result in *less* criminal activity around the offender's home.

This area, of relatively higher risk to the offender of identification, the so-called *buffer-zone* (Brantingham & Brantingham, 1984) exists as a sort of bulwark between the offender's *activity* space (e.g., home) and their criminal *opportunity* space. Research findings are mixed with regard to the existence of a buffer zone, some studies show confirming evidence (e.g., Canter & Larkin, 1993; Dern et al., 2005; Rossmo, Davies & Patrick, 2004) while other studies refute it (for example, Levine, 2005). However, It seems plausible that a buffer zone may exist and that it may be closely related to population density such that offenders operating within areas of high population concentration (e.g., urban areas) are less likely to have 'buffer zones' as these areas offer greater anonymity than less densely populated areas. Additionally, Goodwill and Alison (2005) argue that, particularly for violent and sexual crime series, the buffer zone may expand from one offence to the next as the offender's perception of risk and consequence of detection increases. At the least it is conceivable that an offender's perception, his psychological understanding, of the area that he offends in influences whether he feels there is an increased or decreased risk of identification due to the familiarity or anonymity the areas provides. Applying this to geo-OP would require the reverse logic, potentially making an inference about how much risk the offender perceived to predict how familiar they might be to that area.

3.3 Journey to Crime (JTC)

As discussed in Section 3.1, the 'psychological centre' of most individuals lives is their home (Gabor & Gottheil, 1984), this is also literally the case in strictly geographical terms (Canter & Larkin, 1993). Research has consistently found that most offenders, across many types of crimes, commit their offences in areas that form a routine part of their lives (e.g., Cornish & Clarke, 1986; Rengert, Piquero, & Jones, 1999) and thus the central point of their offending is hypothesised to be their home (Canter & Gregory, 1994; Canter & Larkin, 1993; Snook et al., 2005). Further, it has been theorised that offenders travel outwards from their homes to commit offences based on various psychological, geographical and situational aspects (Goodwill & Alison, 2005). Researchers have utilised this theoretical approach by considering that the *distance* an offender travels to their crimes from their home (Journey-To-Crime, or JTC) may be related to various aspects of their character or situation.

3.3.1 Distances & Offence Characteristics

Overall, the JTC distance an offender travels has been found to vary between crime types (Goodwill & Alison, 2005; van Koppen & Jansen, 1998) and across individuals (van der Kemp & van Koppen, 2007, for example). Goodwill and Alison (2005) illustrated that serial murderers travelled in a far more distributed pattern than serial burglars and rapists, based on sequential angulation scores and pattern-analysis techniques. However, the displacement *within* a sexual offence (e.g., contact location compared to the offence location compared to the release/disposal location) has evidenced no clear patterns (Dern et al., 2005; Rossmo et al., 2004). Across individuals, research (see Wiles & Costello, 2000) has indicated that the more person-targeted, expressive offences (e.g., rape, murder) tend to occur much closer to the offender's anchor point or home base (e.g., shorter JTC distances) than object-targeted, instrumental offences (e.g., burglary, armed-robbery, etc.). For example, Van Koppen and Jansen (1998) found that bank robbers will travel farther, typically over 10kms, for greater rewards, whereas rapists appear to travel on average just 2.5 km (Rossmo, 2009). Dern et al. (2005) illustrated that planning rapists had significantly larger JTC distances than those that acted spontaneously. Further, Santtila et al. (2007) and Rossmo et al. (2004) found sexual offenders that used vehicles and exhibited planning in their offences travelled farther than sexual offenders who didn't. Clearly the access to a vehicle enables an offender to cover greater distances and has thus been found to be positively correlated to distance travelled in German sexual murderer body disposal sites (Snook et al., 2005) and Dutch robbery crime locations (van Koppen & Jansen, 1998).

Temporal aspects of an offence are also posited to relate to JTC distance (Ratcliffe, 2006), in which 'weekend' rapists in the UK travelled longer distances than 'work-week' offenders (Canter & Gregory, 1994), as did day-time as opposed to night-time rapists (Santtila et al., 2007). Mokros and Schinke (2006) offer a hypothetical explanation of disparate JTC distances based on temporal aspects by suggesting that offenders who work during the week may be more socially integrated into their surroundings and thus may feel the need to move either farther away from their home (typically on weekends) or to attack at night to avoid being identified by potential witnesses. Similarly, Rossmo (2000) suggests that the opportunity for night-time offences is spatially biased towards certain activity areas: a rapist is much more likely to find a suitable victim in an urban night-time entertainment area or arterial routes of a city than in a rural area in general. In fact, utilising the temporal aspects of a crime series to predict the home-base of an offender was introduced by Kind (1987) in the 'Yorkshire Ripper' investigation in the UK. Kind (1987) combined the time when murders were committed with assumptions about the offender's routine activities, concluding crimes later in the day would be closer to the offender's home base.

3.3.2 *Distances & Offender Characteristics*

Research has consistently shown that many offender characteristics are related to JTC distances and the overall spatial behaviour of offenders. For example, JTC distance varies with gender (Wiles & Costello, 2000), race (Canter & Gregory, 1994) intelligence (Pettiway, 1982) and arguably age. Some research has found age and JTC distance in rape offences to be positively correlated (Dern et al., 2005) while other studies have found no significant age-related trends (Rossmo et al., 2004; Wiles & Costello, 2000). However, age-related studies may be confounded by the fact that younger offenders may commit crimes closer to home due to lack of vehicle access (Dern et al., 2005).

Other relationships between offender characteristics and crime distances have also received mixed support (Mokros & Schinke, 2006). For example, across several disparate crime types, offenders with previous convictions appeared to travel longer distances (Gabor & Gottheil, 1984; Rossmo et al., 2004), whereas others have failed to find such a relationship (Dern et al., 2005).

The inconsistency of findings relating JTC distances to offender characteristics is perhaps not surprising; offenders, particularly across crime types, will make risk versus reward and cost versus effort judgements disparately (Goodwill & Alison, 2005). This has an effect on comparative distance-decay readings which will inevitably reveal that different types of offenders may form subgroups where inter-related JTC distances are significantly different than intra-subgroup or aggregated group-level distances. This has lead researchers (see Santtila, Zappala, Laukkanen & Picozzi, 2003, for example) to suggest that JTC research, based on distance-decay modelling, predicting offender movements are limited in use, if not calibrated on the subgroup (e.g., offence type) and area (e.g., city or neighbourhood) under scrutiny. Moreover, as JTC studies are not typically focused on *why* the particular pattern or distance-decay model exists for a given group of offenders, there is little prospect of applying these findings in real-world investigations.

4.0 Distance-decay models and Computerised Geographical Profiling (CGP) systems

GP has seen rapid growth both in academic interest and practical use. As crime analysis in general has increased, policing agencies around the world have begun to increasingly focus on the operational use of geographic profiling in case investigations (Van Schaaik & van der Kemp, 2009). Although in recent years the breadth of operational issues and support a geographical profiler may be involved in has increased (see Section 5.2 for discussion), the primary role of geographic profilers is still often to predict offender anchor points (e.g., their home, place of work, etc.) through the

computerised analysis of crime locations (e.g., approach, abduction, offence, release sites, etc.). There are several computerised geographical profiling (CGP) systems used by police investigators and geographical profilers and these mainly differ in how they apply various forms of the distance-decay function to produce probabilistic predictions of offender anchor points.

Dragnet (Canter et al., 2000), *Rigel* (Rossmo, 2000) and *CrimeStat III* (Levine, 2010) are the most common CGP systems. *Dragnet* utilises a negative exponential function for the computation of distance-decay so that as an offender moves away from their home-base the probability of offending decreases exponentially. *Rigel* utilises a distance decay function with two parts, the first being a positive linear exponential function and the second a negative exponential function. Rossmo has not stated explicitly in his published work on Rigel, but it can be hypothesized that the first positive linear function reflects the assumption of a 'buffer zone'. *CrimeStat* III can utilise a number of JTC distance decay functions, including a Bayesian JTC module, or calibrated functions based on an analysts' or researchers' own data. Similar to Dragnet and Rigel it creates a probability grid in which each observation falling into an area (or 'bin') is replaced by a density function (or 'kernel'). The sums of those probabilities across the search area indicate the most likely areas that an offender may live Santtila et al., 2007). Density functions are used to enable a 'continuous distribution' without probability 'borders' giving a more realistic interpretation of the probability distribution for offending (Santtila et al., 2007, p. 5).

Although these approaches are useful tools for mathematically predicting likely areas of the offenders' anchor points (e.g., home, work, etc.), they are limited by the fact that they all assume a uniform distribution of targets across the search area by default (Kent & Leitner, 2009). However, the latest version of CrimeStat (ver. 3.3) can utilise a Bayesian origin-destination function that can model previous crime activity and offender home-base backcloths (Levine, 2010). A study by Van Koppen, Elffers and Ruiter (2011) sought to develop an *ex ante* test based on the distribution of targets to determine if geo-OP was possible for a particular series. Although the results proved accurate in determining if a crime series followed a specific distance-decay pattern, it is still unclear what influence that may have on the ability to provide useful geo-OP advice. Nevertheless, if target backcloth is ignored much of the information needed to make an accurate probabilistic estimation of the offender's anchor points cannot be made (Bernasco, 2007). Next to the distribution of targets, the offenders' activity space is also influenced by environmental factors such as lakes, rivers, highways (Kent & Leitner, 2009) and also by social boundaries, such as neighbourhoods (de Poot, Luykx, Elffers, & Dudink, 2005), which are again, not considered. The saturation of targets is itself related to the environmental characteristics of an area; high-rise buildings might give less

opportunity to commit burglaries, for instance. The creators of Dragnet, Rigel and CrimeStat all purport that these factors should be taken into consideration when 'applying their tools' by 'trained geo-profilers', however, how this is to be done has not been explicitly stated or published (Snook et al., 2004, Van der Kemp & Van Koppen, 2007).

Finally, most CGP systems, and the vast majority of the GP and JTC research, rely on using straight-line (e.g., Euclidian) distance to compute JTC and home-base predictions (Kent, Leitner & Curtis, 2006). As Kent et al. (2006) point out this means that current profiling models assume an isotropic surface, where impedance is uniform in every direction. As a result, contemporary GP techniques do not accommodate the inherent variations of an area, such as the influence of a particular transportation network, landscape features, land-use policies, physical and psychological boundaries, etc. However, on a different note, Kent et al. (2006) suggest that a more realistic way to model the geographic space offenders are utilizing is to use a street-grid system (e.g., Manhattan distance) that better captures the potential travel patterns of offenders. Although Manhattan distance may be a more appropriate measure for North American cities, that typically have a grid-style pattern of roads and transportation networks, many cities in Europe have circular-style grid pattern in which a Euclidian approach may be more effective (Canter & Youngs, 2008a). In this regard, a novel method proposed by Trotta, Bidaine, and Donnay (2011) does take account of the road networks surrounding crime locations investigating the effect of driving time and speed. Clearly, such an approach has a greater potential benefit for real-world investigative applications than elaborating on distance-decay functions that ignore important environmental aspects.

4.1 Computerised Geographical Profiling Systems in Practice

In terms of geographical profiling success, van der Kemp and van Koppen (2007) summate that geographical profiling '*…has the ring of being very successful, but no study to date demonstrates that it is successful in helping police investigations in more than a small percentage of cases*'. As only a few cases seem to reach the threshold criteria (Rossmo, 2000) for applying geographical profiling analysis, this may not be that surprising. For example, Rossmo argues that in order to establish a pattern, Rigel requires at least five related or linked crimes (Rossmo, 2000). Research by Snook, Zito, Bennell and Taylor (2005) contest Rossmo's assertion citing a lack of substantial empirical underpinning of the criterion. However, more recent research by Leitner, Kent, Oldfield and Swoope (2007), replicating the work of Newton (1988) on serial murder, has shown that predictions of an offender's 'haven' (e.g., a home base or anchor point) becomes successively more accurate after the 5th offence in a series in urban burglary data. Nevertheless, in reality, the point may be moot as

recent research by Knabe-Nicol and Alison (2011) report that UK geo-profilers nevertheless provide investigative advice in a substantial amount of single offences (39% of cases from 2002-2007) often in which only one crime location is known.

4.2 The Man (e.g., heuristics) vs. Machine (CGP systems) debate

A publication by Snook, Canter and Bennell (2002; later followed by Snook, Taylor, & Bennell, 2004) called into questions the benefit of computerised geographical profiling (CGP) systems, such as Rigel, Dragnet and CrimeStat. An academic debate emerged between Rossmo and Snook and colleagues, the latter presenting empirical evidence that students using simple heuristics could predict an offender's home-base as accurately as a CGP system (Rossmo's Rigel CGP) using simple geo-profiling heuristics. Although this debate lead to an important increase in research empirically scrutinising CGP systems, it also spawned numerous research studies that sought to produce the most optimal distance-decay algorithm for use in CGP systems using a multitude of methodologies (see Kent, Leitner, & Curtis, 2006, for review). However, it is suggested that the search for the most optimal method or algorithm for determining the home-base of an offender from *only* x/y coordinates on a map perhaps misses the overall point of the GP – to examine the geographical movements and decision making of an individual offender for the purposes of identifying or prioritising areas of interest or, even better, offenders. In other words, the pragmatic utility of using *only* a CGP system or *only* a heuristic approach and not considering the target type, distribution or attractiveness (Bernasco, 2007) is questionable on a number of compelling grounds (for further review, see Stangeland, 2005). By the same token, the results of Paulsen (2006) are quite telling, no matter whether anchor point predictions were based on human judgement, geometric principles or distance decay functions, they were all still off the mark.

5.0 Pragmatic use of Geographical Offender Profiling (Geo-OP)

5.1 Why are those pins, in that pattern on that particular map?

For some time, the act of (literally) 'sticking pins on map' to indicate the x/y, northing-easting's or GPS coordinates of crimes and crime series by police and researchers alike has been used to display and analyse geographical crime patterns of individuals and groups (see van Schaaik & van der Kemp, 2009, for review). With regard to GP much of the research focus has been on developing mathematical and computational models of serial offenders' 'pins on the map' (e.g., offences) to predict an offender's home-base or anchor point(s) (Canter & Youngs, 2008a). Yet, a

major limitation of GP research has been that the crime location 'map' (e.g., topography, transport routes, social nodes, etc.) has largely been neglected (Kent & Leitner, 2009).

Further, and perhaps of even greater relevance to GP is the fact that only a handful of studies have attempted to understand the psychological aspects of *why* the pins are where they are (e.g., Goodwill & Alison, 2005; Rossmo, 2000; Canter & Shalev, 2000). It should be apparent from the discussion thus far that GP is a complex process and cannot be reliably reduced to the prediction of an offender's home base from x/y coordinates, irrespective of considering the influence of the geographic area, or the routine activity of the probable offender (e.g., *why* that 'space'? *why* then? *why* that route? etc.). As Van der Kemp and Van Koppen (2007) postulate using that information is potentially the best way to fine-tune geographical profiling. Therefore, in light of the limited research exploring the complexities and reliability of GP methods one might question what it is that geo-profilers actually advise on, what that advice is, and how it is derived?

5.2 Beyond the pins: Revealing how UK geo-profilers operate

Knabe-Nicol and Alison (2011) carried out the first detailed, qualitative analysis to explore and explain the various stages and demands of the decision making processes of geographical profilers in the UK. Using Applied Cognitive Task Analysis (ACTA), Knabe-Nicol and Alison (2011) were able to explicate the different decision making stages, their degree of difficulty, the most common errors that can be made, and the cue and strategies to counteract possible pitfalls in the geographical profiling process undergone by UK geo-profilers.

Importantly, Knabe-Nicol and Alison's (2011) research revealed that the analysis of spatial information by UK geo-profilers was not limited to simple x/y map location(s) analysis but more often involved identifying the activity space and routes of victims, offenders, and the general public. In other words, geo-profilers did seem to be more concerned with how individuals *use* the geographical space, what *influences* that use and what that can tell us about a number of aspects of the offence or offender. Accordingly, they found that a fundamental part of the process used by geo-profilers was to examine offences from an environmental criminology viewpoint: Did the offender meet his victim while carrying out a routine activity (e.g., the attack was somewhat opportunistic) or does he have intimate knowledge of that area from previous exposure (for whatever reason) to it and has returned to it to offend (e.g., there was an element of planning involved in the attack)? Geo-profilers would also scrutinize the various aspects of crime scene information, the locations of the offences and the behaviours observed based on the least effort principle (as discussed in Section 3.2), such as why did the offender not take the shortest escape route?

This approach, far removed from the mathematical process of pinpointing the offender's home-base based on x/y crime location coordinates, enables geo-profilers to offer advice on any offence or series of offences, even those in which the offender may be a non-local 'commuting' or 'poaching' offender. However, it is still difficult to estimate the reliability or validity of their methods when one recognizes that there is a dearth of empirical research investigating the relationship between routine activity theory and GP. Again, this begs the question; just what are they using to make their investigative recommendations? Further, are the UK geo-profilers unique in their approach or do geo-profilers from other countries use similar strategies? Although this initial research by Knabe-Nicol and Alison is compelling and tantalizingly insightful, it still leaves many questions unanswered and requires further investigation.

5.3 Offender "Hunting Style": The potential for behavioural integration in Geo-OP

Although the research into the integration of routine activities and GP is still developing, a tentative theory on how sexual offenders may make geo-spatial decisions to locate and attack victims has been offered by Rossmo (2000). Rossmo proposed that offenders employ various 'hunting patterns' based on their geospatial movement and behavioural characteristics - acknowledging that geo-spatial movement is a dynamic decision making process. Rossmo delineates four types of hunting patterns the: hunter (a.k.a. marauder), poacher (a.k.a. commuter), troller, and trapper. Hunters, as the name implies, are offenders who actively seek out their victim. They tend to use their place of residence as an anchor point before engaging in crime. Poachers are also active in their pursuit; however, they tend to travel further distances, even to other cities, in order to find their victims. Trollers offend opportunistically, coming across their victims while they are engaged in non-predatory activities, and seizing the chance when they become aware of it. Trappers choose to situate themselves in positions that provide them with the largest accessibility to a particular victim type. These offenders choose to work in professions such as nursing or find means to lure victims into their homes.

It is important to note that although these hunting types are theoretically possible and may make some intuitive sense they are still being empirically validated (Beauregard, Rebocho & Rossmo, 2010). As Beauregard, Rossmo and Proulx (2007) point out: no explanation is provided as to why offenders choose one method over another. Nevertheless, as stated by van der Kemp and van Koppen (2007) the process of relating behavioural inferences to geo-spatial movement patterns will no doubt result in a more fine-tuned and accurate GP approach.

5.4 Geographical Offender Profiling Validity

As with most investigative methods it is quite difficult to assess to what extent geographical profiles have actually helped in the investigation. For example, a geo-profile may help to define the area for door-to-door enquiries, it may indicate a potential linked crime to a series in question, and/or it may pinpoint an offender's residence or simply estimate an offender's activity space, among other geographical aspects and investigative uses (Rossmo, 2000). However, some aspects of a report may help while other aspects may not and some may even hinder an investigation. Unless a geo-profile specifically names the offender it is difficult to ascertain the extent to which it helped (or hindered) the investigation – and this is rarely the case.

In practice, a number of problems arise in estimating the accuracy of geo-profiles (see van der Kemp & van Koppen, 2007, for a detailed discussion). For example, how to assess the accuracy of a geo-profile, that is succinctly and comprehensively based on compelling (e.g., state of the art) theoretical and empirical research when in actuality the offender deviates from the 'norm'? Is a well-informed well-reasoned geo-profile 'incorrect' if the offender lives outside the predicted area? Is it possible to be 'correct' based on our current knowledge (e.g., the predictions are theoretically and empirically sound), yet, still, 'inaccurate'?

6.0 Integrating Routine Activity Space in Geographic Offender Profiling

As discussed previously, research integrating routine activity theory into geo-profiling is sparse. Instead much debate has surrounded how one should go about determining the likely home base of an offender based on the x/y coordinates of their crimes (see sections 2.3-2.4). This line of research is likely to be futile in real pragmatic terms of aiding police investigations. For example, even if the 'perfect' algorithm existed to pinpoint exactly where, theoretically, an offender should live to the utmost precision, it still may be inaccurate. The offender may live, work, play, somewhere else. The point is clear that crime locations offer investigators and researchers alike a chance to know one particular thing about the offender; that the offender has been there, for some reason, and has offended. Thus, in line with Brantingham and Brantingham's (1984) crime pattern theory, we may now know something about the offender's *activity* and *opportunity* space.

Recently, several researchers have supported this view suggesting that GP analyses must be combined with other types of information, such as who utilises the 'space' around crime locations, to increase accuracy and reliability and/or to ultimately *identify* an offender (Bichler, Christie-Merrall, & Sechrest, 2011; Goodwill & Alison, 2006; Stangeland, 2005; van der Kemp & van Koppen, 2007). Importantly, this 'other' information need not only be additional crime scene information but archival information in general; phone records, land registry ownership, hospital admissions, parking

infractions, etc. Historically, police investigators combined geoprofiling home-base predictions with police records of previous convictions, using this information to focus their searches and enquiries around the 'usual suspects' – those already known to the police. In addition, police would prioritise search areas for the assailant within the immediate vicinity of the crime(s) to conduct door-to-door interviews, pamphlet drops and potentially DNA swabbing (Rossmo, 2000). However, as Stangeland (2005) points out:

> *An intelligent criminal, of middle-class background, is less likely to be found in police files. However, the possibility of tracking him down through other kinds of records increases. Precisely because he lives a normal life, he is more likely to be a homeowner, registered on the local census rolls, to have a mobile phone, credit cards, and a car in his name. The possibility to combine two or more known data on the person and perform a computer search in public or private registers can reduce the circle of suspects*. (p.467)

The current authors suggest that it is precisely this combination of various types of information databases, most readily available and in the public or semi-public domain, that will enable investigators to identify which individuals are utilising a specific area (around a crime location) or the entire area defined by a crime series. In other words, whose *routine activity space* do these crime locations represent?

6.1 Investigative strategies: Developing and prioritising suspect lists based on a routine activity approach

As discussed throughout this chapter, the advancement of GP will be as a result of the integration of information beyond x/y crime coordinates and other mere mathematical calculations (e.g., distances between crime sites, JTC distances, etc.). It is suggested that crime locations offer insight into the activity space of an offender and these are likely areas that the offender routinely visits. Recently, researchers have begun to recognise that identifying the routine activity space of offenders is an important aspect of geo-spatial analyses. Bichler, Christie-Merrall and Sechrest (2011) suggest that activity space, specifically points of 'social' focus (e.g., gathering points), may influence offender distance-decay functions and in turn GP and CGP systems.

Within a GP paradigm ,with the aim to predict or prioritise *who* has committed an offence, it seems of great importance then to determine a) *who* uses that area and b) *what* that area looks like. In terms of *what* an area looks like, geographers and criminologists have a long history of

investigating the topographic, social and transportation features associated with that area, yet arguably those have not, as of yet, been integrated into mainstream GP research or CGP systems. In fact, in relation to GP research the topographic characteristics of the area of the crimes is seldom considered giving rise to the chance that home-base predictions will be in a lake or an airport runway (Santtila, 2010). Importantly, recent JTC research has begun to integrate topographic features of the area under study to improve JTC estimates (Kent & Leitner, 2009), however, improvements have been cited as 'inconsistent'.

In determining *who* utilises the activity space surrounding a crime location the obvious first step is to identify who lives (or perhaps works) in the area. In other words, who 'belongs' or has reason to be in that area. Identifying who lives and works in the area can be achieved through various archival and public records as well as through door-to-door enquiries. Other information such as traffic violations, store receipts, hospital admissions, even information on who are walking dogs or regular joggers in the area may help to determine who *routinely* uses that area. Archival records such as census enrolment, tax records, library card ownership, General Practitioners registrations, school enrolment and attendance, and even birth records (e.g., home-towns and links to the community) could establish links between the area(s) and who routinely is in it.

In an ideal situation one could generate lists of individuals who are routinely using the activity space around each crime location of a linked series and cross-reference the lists to prioritise individuals. This is an admittedly lofty goal and in some cases may not generate or prioritise the individual responsible, but in arguably the majority of cases the offender will be somewhere on those lists. It is then up to researchers and investigative expertise to develop methods to identify or prioritise the offender responsible.

6.2 Concluding comments on the need for a routine activity integrative approach to GP

As discussed throughout this chapter, current GP research and supporting CGP systems may help us to make estimates and judgements about the activity space (e.g., home-base and/or anchor points) of an offender. However, greater GP accuracy and precision in identifying the unknown offender will undoubtedly come from research that integrates analysis of crime locations (e.g., x/y coordinates), features of the geographic location (e.g., topography, routes and social nodes) and the routine activity of offenders. Pragmatically, geo-profilers must utilise all manner of other types of information relating to the activity space surrounding crime locations to identify links to other crimes or series and to identify who is utilising that particular activity space. In conclusion, the current authors advocate that the integration of environmental criminological theory, particularly

that of routine activities, into current GP research and CGP systems as a necessary next step in advancing geographical offender profiling.

Related Entries

- Crime Location Choice
- Crime Mapping
- Criminal Investigative Analysis
- Criminal mobility and sex offending: Looking beyond the journey to crime
- Criminal Profiling
- Geographic Criminology
- Hot spots and place-based policing
- Integrating Rational Choice and Other Theories
- Investigative Psychology
- Linkage Analysis
- Near repeats and crime forecasting: What we know, what we don't and what might not know we don't know
- Offender Decision Making & Behavioral Economics
- Profiling Arson
- Profiling Homicide
- Profiling Sexual Assault
- Rational Choice and Prospect Theory
- Rational Choice Theory and Deterrence in sociology/criminology
- Rational Choice Theory and Deterrence – Bayesian Updating
- Rational Choice Theory Explained
- Residential Burglary
- Role of Place in Outdoor Serious Violence

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