Effects of residential history on commercial robbers' crime location choices

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Abstract

Many offenders offend near their home. But what about their former homes? Extending crime pattern theory, and combining data on police recorded robberies with data on the residential histories of the robbers and with a database of postal code areas, we demonstrate that offenders are more likely to commit commercial robberies in their former residential areas than in otherwise similar areas they have never lived in. To investigate the role of the residential history in greater detail, we assess whether duration and recency of past and current residence differentially affect the choice of target areas. We discuss the theoretical and practical implications of the findings and make recommendations for future research.

The phrase "distance decay" refers to the finding that the frequency of offending decreases with the distance from the offender's home. Although distance decay has been confirmed time and again in empirical research, it has seldom been the subject of theoretical exploration. Rational choice theorists have emphasized that travel cost minimization can explain the distance decay pattern. Routine activity theorists have argued that the distance decay pattern is typical not only for crime but for most habitual spatial behaviours. However, these are explanations of a fact that has already been shown to be ubiquitous. What is needed is a theoretical perspective that not only explains distance decay but also generates new empirically testable predictions. Building on recent work in this area

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(Bernasco 2010), the present paper articulates such a theory, derives new hypotheses from it and tests them using data on the spatial target choices of commercial robbers.

Various theories in criminology make claims about the mechanisms that give rise to observed spatial patterns in crime. Crime pattern theory (Brantingham and Brantingham 2008) assumes that offending usually takes place within the *awareness space* of the offender. Because former homes continue to be part of offenders' awareness space after they have moved, this theory predicts that former homes still function as anchor points for future crimes. It also predicts that offending near a home where one lived recently is more likely than offending near a home where one lived long ago, and that offending is more likely near a home where one lived for many years than near a home where one lived only briefly. These issues are not only of theoretical importance; they also have practical relevance, because the findings might be useful in criminal investigations by providing guidance in the construction of a geographical offender profile (Canter et al. 2000; Rossmo 2000).

We first review the literature on the role of offenders' residential locations on spatial target choices, and then elaborate the theory and formulate hypotheses. Subsequent sections address data and methods, findings, and conclusions and discussion, respectively.

Residential location and spatial target choice

Various studies have explored the relation between residential mobility and criminal propensity (LaVigne and Parthasarathy 2005; Tittle and Paternoster 1988) and criminal victimization (Dugan 1999; Xie and McDowall 2008a, 2008b). The present study examines a different issue. It addresses the question of whether and how an offender's previous residential areas have an influence on where he or she commits crimes. Thus, the focus is not on *whether* but on *where* crimes are committed. More specifically, the objective is to determine whether offenders tend to offend near their current and past homes. Although a very comprehensive literature documents the tendency of offenders to offend near their residence (e.g. Van Koppen and Jansen 1998; Wiles and Costello 2000), the investigation of the role of past residence leads into barely explored territory. Until recently, all evidence was anecdotal. Rossmo (2000) reported that some serial murderers killed their victims in the proximity of a previous residence, and Curman (2004: 111–34) described an arsonist who, after moving to a neighbouring municipality, continued to set fires near her former residence.

Bernasco (2010) systematically studied the influence of past and current residence of crime location choices for burglary, robbery, assault and theft from a vehicle. He found that offenders not only commit crimes near their current home but also tend to commit crimes near their former homes. The present paper replicates and extends Bernasco's work by focusing on commercial robberies and by using data that cover a much larger geographical area.

Extending crime pattern theory

A central premise of crime pattern theory (Brantingham and Brantingham 2008) is that offenders learn about their environment in going about their legitimate everyday activities. The spatial aspects of habitual travel behaviour are described by four concepts.

An *activity node* is a place where one normally stops to perform activities for more than a trivial amount of time. Activity nodes include a home, a workplace, a shopping strip, and the homes of family and friends. *Paths* are the habitual routes that people take from one node to the other, for example from home to work. Nodes and paths together form an individual's *activity space*. The *awareness space* includes the activity space and the "area normally within visual range of the activity space" (Brantingham and Brantingham 2008: 84). Supported by empirical evidence (Gärling and Axhausen 2003; Hanson and Huff 1988), crime pattern theory emphasizes the *intrapersonal stability* of activity nodes over daily and weekly time cycles and the repetitive character of activities along multiple dimensions: many people travel the same routes from the same origin to the same destination on the same weekdays around the same time of day using the same mode of travel (car, train, bus, bike or a combination).

Activity space changes

Studies that measure daily travel patterns repeatedly over longer periods, such as months or years, demonstrate much stability from week to week, but also find considerable variability from year to year (Mannering et al. 1994). Nobody's set of activity nodes is fixed forever, and even very predictable people with highly habitual travel patterns will change some day (Horton and Reynolds 1971).

Changing our activities usually implies that we acquire new activity nodes at the expense of others, so that these other activity nodes disappear from our lives, and in time also from our memories. To incorporate change more explicitly into crime pattern theory, we will reserve the term *activity space* explicitly for an individual's set of *contemporaneous* activity nodes and the paths between them, whereas the term *awareness space* will be used for a potentially broader collection of nodes and paths, one that includes not only the area normally within visual range of the activity space but also the former nodes and the paths between these former nodes. Thus, the extended definition is:

> Awareness space is a person's current activity space as well as his or her activity spaces in the recent past, including the area normally within visual range of these activity spaces.

This definition of awareness space is more encompassing than activity space – not only in a spatial but also in a temporal sense. It includes areas around activity nodes and paths, and it includes nodes and paths that have been part of the individual's activity space until recently.

Effects of changes in activity nodes on awareness space

Life events that involve relocation or a switch of activity nodes require a change of spatial routines. New nodes and paths are discovered and prior nodes and paths are unlearned. Although changes in activity space may be abrupt, the effects on awareness space are delayed. If a particular place ceases to be an activity node, the individual's memory image of it fades gradually. At the same time, a new node and paths to this node are discovered little by little. In sum, it takes time to become familiar with new places and routes and to forget former ones.

Many life events cause changes in our activity nodes and paths. We change jobs, switch leisure activities, or meet new friends and visit their homes. Most people discover new places and new routes in their environment all the time, and their activity space is subject to continuous change. A change of residence, however, has a particularly strong influence on an individual's activity space. Moving residence strongly affects all daily routines, because home is the major anchor point where most daily routines start and end (Golledge and Stimson 1997: 279).

Hypothesized effects of residential history on crime location choice

Because home is the central anchor point of a person's activity space, the addresses and periods of offenders' current and prior residence are imperfect but nevertheless useful approximations of their awareness spaces. Making this assumption, access to offenders' residential histories as well as their criminal histories provides an excellent starting point for testing the role of awareness space in crime location choices. In addition to replicating prior results on distance decay, we formulate four new hypotheses. They are derived from the theoretical elaboration, in the previous subsection, of how personal residential history affects awareness space.

The first hypothesis modifies distance decay with respect to the duration of residence. People who only recently moved into their current home are normally less familiar with the local environment than people who have lived for many years in their current area of residence. As offenders, the former should consequently be less likely to offend locally than the latter.

> *Hypothesis 1:* Offenders are more likely to offend in a current area of residence where they have lived for a long time than in a current area of residence where they (have) lived for only a short period of time but that is comparable in terms of criminal opportunities.

Note that 'comparable in terms of criminal opportunities' is the 'all other things being equal' condition that is usually implicitly added to a hypothesis. It is included explicitly here to emphasize the type of comparison implied: the area where the offender lives is to be compared with areas that are similar with respect to all other relevant characteristics for choosing a location for commercial robbery.

The second hypothesis asserts that, because areas of past residence will remain in an offender's awareness space, they are more likely to be targeted than areas that have never been the offender's area of residence.

> *Hypothesis 2:* Offenders are more likely to offend in an area where they formerly lived than in an area where they never lived but that is comparable in terms of criminal opportunities.

Additional challenges for the theory are sought by examining two supplementary hypotheses that condition the role of former residential areas temporally. They are based on the argument that the extent to which a former residential area is part of an offender's awareness space depends on the duration and recency of the offender's experience with

the former residential area – how long the offender has lived in the area and how long ago the offender departed from the area.

As has been argued in support of hypothesis 1, length of residence is expected to matter. The image of a former residential area will be more accurate if the individual lived in that area for a long time rather than briefly. If the individual lived briefly in the past residence, he or she is unlikely to have become completely familiar with the environment of that home.

> *Hypothesis 3:* Offenders are more likely to offend in an area where they formerly lived for a long time than in an area where they formerly lived for only a short period of time but that is comparable in terms of criminal opportunities.

In general, the image of a previous activity node will be more accurate when the change of residence is more *recent* because the memory is still fresh and because the image itself is up to date. When time passes, not only does memory decay but the environment of the former residence will also be subject to objective changes, as buildings are demolished and rebuilt, shops change owners and new groups of residents move into the area.

> *Hypothesis 4:* Offenders are more likely to offend in a area where they formerly lived until recently than in a area that they left longer ago but that is comparable in terms of criminal opportunities.

Data and methods

Data sources

The first data source is the National Commercial Robbery Registration System (LORS), which is managed by the Dutch National Police Services Agency (KLPD). The LORS is an information system specifically designed for strategic and operational analyses in criminal investigations of commercial robberies. It includes information on all commercial robberies in the Netherlands that have been brought to the attention of the police, and on the offenders who have been charged with the robberies. Commercial robberies are those that conform to the following criteria:

- (an attempt to) take away or extort money or goods;
- the use or threat of violence forced the victim to hand over the money or goods;
- the incident took place in a closed place, screened off from public space (e.g. store, restaurant). Robberies from taxi drivers, couriers and other commercial transport services are also registered in the LORS, but were excluded from this research because of ambiguity in the geocoding of the location at which the robbery took place.

The second data source is the population registration data held in the Nationwide Citizen Information System (GBA). Dutch municipalities and several other agencies use this system in order to keep track of the birth, marriage, divorce, childbirth and residential addresses of all Dutch citizens. The GBA system incorporates historical information,

including the former addresses of Dutch citizens. When a citizen leaves the country (semi) permanently, he or she remains in the system and is registered as residing abroad. When a person is detained for more than three months, he or she is registered as residing at the address of the penitentiary. The GBA system allows the reconstruction of the residential histories of all offenders from 1992 onward.

In the present analysis, the residential history of a person is a list of one or more records that contain the postal code and the first and last date of residence. Using this list, for every offender four variables were calculated for every postal code area in the Netherlands:

- Whether the offender lived in this postal code area at the time of the robbery (yes or no)
- Whether the offender had ever lived in this postal code area before the robbery (yes or no)
- How long the offender had ever lived in the postal code area before the robbery. Multiple residential periods in the same postal code area were summed. This variable equals zero if the person did not live and had never lived in the area before the robbery.
- If the person lived or had lived in the postal code area before the robbery, how much time had passed since the person had moved out of the area. The variable had no value if the person had never lived in the area, and equals zero if the person currently lived in the area.

The third source of data is a database containing demographic, social and economic information on all postal code areas in the Netherlands. There are 4006 postal code areas nationwide; they have an average population size of 4900 and an average number of households of 2100. In terms of size, shape and topography, the postal code area is a useful spatial unit of analysis because it approximates the area one would expect people to be familiar with if they lived within it. Its boundaries have been designed with post delivery services in mind, physical restrictions on travel within the area are minimal, and it invites local travel by foot and bicycle, modes of travel that provide ample opportunities to learn about the environment.

Eight different attributes of the 4006 postal code areas have been included as control variables in the analyses, quantifying the 'all other things being equal' condition in the hypotheses. One of the control variables is the total floor area of retail businesses, a straightforward measurement of the opportunity structure for commercial robbery. The distance to the nearest highway ramp was included as a measure of the accessibility of entry and escape routes. The mean value of residential property measures affluence in the area. The other variables – population density, population size and population percentages of 15–25-year-old, foreign-born and single residents – were included as proxy indicators of social disorganization.

Case selection

We first selected all 4657 robberies in the years 2004 and 2005. Using robberies before this period would have made the registered pre-offence residential histories shorter and

thus less useful for the analysis. Subsequently the 1539 robberies were selected for which at least one person had been arrested and charged. To keep the theoretical problem and the data structure simple, robberies committed by offender groups were excluded. We selected only the 398 robberies that had been committed by a solitary offender (as reported by victims or bystanders). In order to be able to link records from the three data sources, 352 robberies were selected for which the postal codes of the robbery were known and where the robber's data, including his or her residential history, were available in the GBA system. Of these 352 cases, another 76 offenders were registered in the GBA as living abroad (without a specified address) *at the time of the robbery*. Because the distance between the current residence and the crime location could not be calculated in these cases, 276 robberies remained for testing the hypotheses.

Table 1 summarizes the main characteristics of the offenders (age, gender, ethnic origin, address stability) and the robberies (distance, relation between robbery location and offender's residential history). The relation between the location of the robbery and the offender's residential history speaks most directly to the topic at hand. A considerable percentage of the robberies were committed in the offender's current home postal code area (18 percent) or in a former postal code area (17 percent). Using a threshold value of 2 years, Table 1 also differentiates current and former homes by the duration and recency of residence.

Analytical strategy

To test the four hypotheses on the role of residential history in robbers' target location choices, a method is required that compares the postal code areas that offenders targeted with alternative postal code areas that they did not target. In other words, how can it be decided whether or not residential history is a relevant aspect of robbery location choice? To this end, we use the conditional logit model, a regression model that explains the outcome of a decision-maker's choice amongst discrete alternatives (also see Bernasco and Nieuwbeerta 2005; further details available from the authors). In the application of this model to crime location choices, the dependent variable is the probability that an area is chosen as a crime location by the offender. The independent variables include generic area characteristics such as population size and affluence, as well as offender-specific characteristics, in particular the distance of the area from the offender's residence. In the present analysis and in Bernasco (2010), the independent variables of major interest are whether, for how long and until what point the area has been part of the offender's residential history.

Findings

Table 2 displays the outcomes of the tests of the hypotheses. Each of the hypotheses is tested separately. Distance is retained as a variable in the tests of all four hypotheses because it should be considered as part of the 'other things being equal' clause. For example, by comparing a former area of residence with a similar area that is not, we need to compare two areas that are located at the same distance from the offender's current home. Because of space limitations and because of their limited relevance for the main

Table 1. Principal characteristics of the sample (*N* = 352)

Variable	Frequency	Percent
Age		
0–19 years	39	11
20–29 years	132	38
30–39 years	118	34
40–49 years	56	16
50–69 years	7	2
Gender		
Male	337	96
Female	15	4
Country of birth		
Netherlands	236	67
Morocco	22	6
Surinam	30	9
Turkey	6	2
Netherlands Antilles	19	5
Other	39	11
Distance		
0–1 km	68	19
1–2 km	42	12
2–5 km	69	20
5–10 km	28	8
10–50 km	53	15
50–100 km	10	3
100–245 km	6	2
Current residence unknown	76	22
Relation between robbery location and residential history		
Current area of residence, of which	62	18
since > 2 years	28	8
since < 2 years	34	10
Former area of residence, of which	59	17
long (> 2 years) until recently (< 2 years)	16	5
short (< 2 years) until recently < 2 years)	12	3
long (> 2 years) long ago (> 2 years)	16	5
short (< 2 years) long ago (> 2 years)	15	4
Elsewhere	155	44
Current residence unknown	76	22
Total	352	100

Sources: National Commercial Robbery Registration System (LORS) 2004–2005, and Citizen Information System (GBA).

arguments presented, the estimated parameters of the eight control variables are not reported in Table 2.

The parameters in Table 2 are *odd ratios*, which indicate how much a one unit increase in an independent variable raises (if the odds ratio is above 1) or diminishes (if the odds ratio is below 1) the probability that the area is chosen as a crime location.

Table 2. Conditional logit models of crime location choice, testing hypotheses on the effects of offender's residential history: odds ratio coefficients (OR) and z-values (robust standard error estimates) (N = 276)

	Distance decay		Hypothesis 1		Hypothesis 2		Hypothesis 3		Hypothesis 4	
	OR	Z	OR	Z	OR	Z	OR	Z	OR	Z
Distance (km)	0.91	−18.0	0.91	−18.0	0.92	−16.7	0.92	−16.7	0.92	−16.7
Current area of residence	11.6	13.9								
Duration										
lived in area > 2 years			15.3	11.1	20.4	12.1	20.4	12.1	19.9	12.0
lived in area < 2 years			9.5	10.0	14.4	11.5	14.4	11.5	14.6	11.5
Former area of residence					8.3	9.9				
Duration										
lived in area > 2 yrs							10.3	8.4		
lived in area < 2 yrs							6.9	6.8		
Recency										
left area < 2 yrs ago									13.0	8.1
left area > 2 yrs ago									6.7	7.4
Never area of residence	1.0	—	1.0	—	1.0	—	1.0	—	1.0	—
Control variables[a]	N.D.	N.D.	N.D.		N.D.		N.D.		N.D.	
pseudo R^2	.44		.44		.46		.46		.46	

Sources: National Commercial Robbery Registration System (LORS) 2004–2005, Citizen Information System (GBA), and National Postal Code Database.

Note: Estimated effects of control variables not shown. All estimated parameters that are shown are significant, $p < .001$ one-sided.

[a] N.D.: not displayed. The area-specific control variables included in all models are (1) total area covered by retail businesses, (2) distance to nearest highway ramp, (3) average real estate property value, (4) number of residents, (5) population density, (6) population percentage aged 15–25, (7) population percentage born abroad, and (8) population percentage single.

The first column of estimates shows the outcomes of the model that confirms distance decay findings in the received literature. The area where the offender lives is 11.6 times more likely to be selected than an equivalent other area and, for each kilometre an area is further away from where the offender lives, the probability that it is chosen diminishes by a factor of 0.91 (i.e. it is 9 percent less likely to be chosen).

To tease out the role of residential experience in the current area of residence, hypothesis 1 distinguishes between current areas of residence where the offender lived for a long time and current areas of residence where he or she lived briefly. The threshold value that distinguishes long from short durations was set at 2 years. Thus, areas of current residence in which the offender has more than 2 years of residential experience are contrasted with areas of current residence in which the offender (has) lived less than 2 years in total. The results, reported in the next column of Table 2, show that offenders who lived more than 2 years in their current area of residence are 15.3 times more likely to offend in their own area of residence, whereas those with less experience in their current home area are 9.5 times more likely to offend in their own area. Although both effects are highly significant, hypothesis 1 applies not to the effects themselves but to their difference. The difference is also significant ($p < .05$, one-sided). This result supports hypothesis 1, and is a clear example of how theory development helps to further specify the well-established finding that offenders have a tendency to offend within the boundaries of their home area. That finding is confirmed, and in addition it is made conditional on the duration of residence.

Hypothesis 2, tested in the next column, is the first hypothesis on the role of former residential areas. It asserts that, in addition to the effects of the current home area and the distance to the current home area, commercial robbers are more likely to offend in areas where they formerly lived. Former areas are indeed 8.3 times more likely to be chosen than other comparable areas, and again the effect is highly significant.

To further scrutinize the role of former areas of residence, hypothesis 3 distinguishes between former areas where the offender lived more than 2 years in total, and former residential areas where he or she lived less than two years in total (the durations of multiple residential spells in the same area, if they occurred, were summed). This contrast is similar to the contrast implemented to test hypothesis 3, but here the role of residential duration in former areas of residence is investigated. The outcomes confirm that former areas are favoured. Former areas of residence are 10.3 times more likely to be targeted than other areas if the offender has lived in the area more than 2 years, and 6.9 times more likely if they have lived in the area for a shorter period of time. Although the difference is in line with hypothesis 3, which states that the likelihood of selection increases with residential duration, it is not significant.

Hypothesis 4 applies not to the duration but to the recency of residence in former areas of residence. The outcomes show, again as hypothesized, that former areas are more likely to be chosen if the offender left the area less than 2 years ago (13.0 times more likely than an area where he or she never lived) than if the area was left longer ago (6.7 times more likely than an area where he or she never lived). The difference between these two estimates is significant ($p < .05$, one-sided).

In testing the effect of duration of former residence (hypothesis 3), the recency of former residence was not included. Similarly, in testing the recency of former residence

(hypothesis 4), the duration of former residence was ignored. However, because spatial knowledge is being learned and unlearned gradually as a function of increasing experience and memory decay, there will normally be a trade-off between duration and recency: to reach the same level of spatial knowledge, less experience can be compensated for by more recent experience, and less recent experience can be compensated for by more experience. To capture this trade-off in a model, the recency and duration variables are combined in the model presented in Table 3.

Focusing on the four variables that define duration and recency in Table 3, it is evident that former areas of long and recent residence have the strongest influence on location choice (17.0) while those of short residence of older date have the weakest influence. The two categories that lie in between in terms of the effect sizes have mixtures of duration and recency, i.e. one being short but recent and the other being long but far back in the past. It would appear that, because their effects are similar in size, recency and duration more or less cancel out.

The threshold value of 2 years that is chosen to distinguish recency and duration in the exploration of the effects of residential history of crime location choice is to some extent arbitrary. We feel it is adequate for a demarcation of the categories and, in addition, empirically this value breaks up the sample data into categories of approximately the

Table 3. Conditional logit models of crime location choice, testing combined hypotheses on the effects of offender's residential history: odds ratio coefficients (OR) and z-values (robust standard error estimates). (*N* = 276)

	OR	Z
Distance (km)	0.92	−16.7
Current area of residence		
Duration		
lives in area > 2 years (long)	20.0	12.0
since < 2 years (short)	14.6	11.5
Former area of residence		
Duration and recency		
long (> 2 years) and until recently (< 2 years)	17.0	6.9
short (< 2 years) and until recently (< 2 years)	9.8	5.0
long (> 2 years) and long ago (> 2 years)	7.8	5.9
short (< 2 years) and long ago (> 2 years)	5.9	5.2
Never area of residence (reference)	1.0	–
Control variables[a]	N.D.	
Pseudo *R*²	.46	

Sources: National Commercial Robbery Registration System (LORS) 2004–2005, Citizen Information System (GBA), and National Postal Code Database.

Notes: Estimated effects of control variables not shown. All estimated parameters are significant, *p* < .001 one-sided.

[a] N.D.: not displayed. The area-specific control variables included in all models are (1) total area covered by retail businesses, (2) distance to nearest highway ramp, (3) average real estate property value, (4) number of residents, (5) population density, (6) population percentage aged 15–25, (7) population percentage born abroad, and (8) population percentage single.

same sizes (see Table 1). However, according to the theoretical arguments developed in this paper, both the growth and the decline of spatial knowledge are continuous and gradual processes rather than discrete and stepwise ones. Therefore, we should expect that the hypotheses should also be confirmed if we varied the thresholds chosen within reasonable limits. All models presented were therefore run with combinations of threshold values of 1 year, 2 years, 3 years and 5 years. In all of the 16 combinations (including the '2 year recency – 2 year duration' presented here as one of them) the estimates confirmed the hypotheses, the main effects of distance, current residence and former residence were significant, and the order of the duration and recency effects was as expected. The statistical significance of the duration and recency effects was typically weak ($p < .05$ one-sided) or absent, as is the case for the results presented in Tables 2 and 3. We attribute this lack of significance to the limited size of the sample.

Discussion

Using unique data on the residential histories of commercial robbers, this study has generated new empirical evidence relating to the spatial behaviour of offenders that supports crime pattern theory. First, the distance decay phenomenon was replicated: it was confirmed not only that many offenders commit crime close to where they live, but also that proximity is a significant choice criterion when other measures of attractiveness are held constant. More importantly, the tendency of offenders to offend near their homes was shown to be conditional on their experience in the local area: offenders who have lived longer in their current area of residence are more likely to offend locally than offenders who have moved to their current area of residence more recently. Next, it was demonstrated that offenders are also more likely to target areas of past residence than other areas that are comparable in terms of distance and attraction value for robbery. Finally, the results suggest a dependence on residential experience: areas of long former residence appear more likely to be chosen than areas of short former residence, and areas of recent past residence appear more likely to be targeted than areas that the offender left a long time ago. Taken together, these findings support the proposition of crime pattern theory that the awareness space of offenders plays a crucial role in their target selection.

With hindsight, the finding that offenders are more likely to offend in areas they are familiar with may seem obvious. Familiarity implies greater knowledge of criminal opportunities and risks, and thus larger profits and lower risks of apprehension on average. However, in familiar areas offenders themselves might also be more easily recognized and identified by victims or bystanders. On these grounds, it has been argued that the geography of offending is characterized by a 'buffer zone', an area around their home in which they avoid offending for fear of being recognized (Turner 1969; Van Koppen and Jansen 1998). Our results do not provide any evidence of the existence of a buffer zone of decreased criminal activity, either around the current home or around former homes.

The evidence we provide is tentative in part because some of the hypothesized differences lacked statistical significance, although their estimated values were consistently in support of the theory. The limited size of the sample, motivated by the wish to have a homogeneous set of offenders and offences, is obviously related to this lack of

statistical significance. More extensive research – research on larger samples, other types of offences and including co-offending groups – is certainly needed to replicate these findings.

Even with larger samples, the need for improved measurement of theoretical concepts remains. The concept of 'awareness space' is only approximated by measuring residential experience. Awareness space is typically much larger than the area around current and former homes. It will often include distant places, including schools, workplaces, the homes of family and friends, and the routes in between these nodes. By following offenders back in time to their past places of residence, we learn more about their spatial knowledge than if we know only their address at the time of the offence. As our findings prove, this improves our understanding of how offenders choose crime locations.

In future explorations of these issues, more direct measurements are needed. The availability of historical offender addresses has been a major strength in the present study, but future studies will probably need to contact offenders themselves and rely on their recollection of events. This is a challenging task, because the quality of the measurements depends heavily on offenders' ability to remember the places and times of past spatial behaviour and past offences (Summers et al. 2010), as well as on their willingness to report them.

Offender accounts may also help to assess the reliability of the residential histories in official government systems. It is likely that the residential addresses in the GBA system do not always reflect where people actually live. Some may forget or be unwilling to report their whereabouts to the authorities. This is highlighted by the finding in our data that, according to the GBA system, 76 offenders lived abroad at the time they committed the robbery. Although it is possible that they indeed resided abroad and returned to the Netherlands to commit a commercial robbery, it is more likely that, by the time they committed the robbery, they already lived in the Netherlands without an updated GBA record. For this particular group the possible lack of reliability became apparent, but similar issues may apply to offenders registered as living in the Netherlands. For example, if someone failed to report their last move, their registered current residence is actually their former address. Because data unreliability tends to mask real effects, our estimates of the effects of residential history are probably conservative.

The finding that offenders commit crimes in areas of past residence might be put to practical use in a geographical offender profile. Geographical offender profiling is an investigative activity aimed at prioritizing the search area for an offender's residence on the basis of where he or she commits offences (Canter et al. 2000; Rossmo 2000). Given a series of crimes attributed to the same unidentified offender, geographical offender profiling attempts to prioritize the search for the offender's whereabouts, usually by minimizing some measure of joint distance from all locations in the crime series.

The results of this research show that, when offenders move away from their neighbourhoods to commit crime, they often travel to areas of previous residence. An awareness of this pattern may help to detect these offenders. For example, in criminal investigations the police could include in their searches not only people who currently live near the crime site but also people who used to live there. Scanning the residential histories of offenders who are already registered in the police files may be the most

tractable initial approach. Therefore, the police are advised to always record the (official as well as unofficial) addresses of their suspects and retain these addresses in their records for future use in investigations. Because many police departments have incorporated geographical information systems into their operational procedures (Weisburd and Lum 2005), these systems could be used to generate flexible geographical queries that include former residences.

Acknowledgement

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